Integrating Cultural Factors in User-Interface Design: The Case of Nasa Colombian Native People

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Integrating Cultural Factors in User-Interface Design: The Case of the Nasa Colombian Native People

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Santiago Ruano Rincón

Glossary

APM Action Port Model. 83

AUI Abstract User Interface. 89

BPMN Business Process Model and Notation. 6, 74, 77, 84, 90

cabildo Annually elected council, main authority of each resguardo. 25, 28, 29, 35

CEFIC Centro de formación integral comunitario (Communal Integral Education Center). 34, 35, 135

CIM Computational Independent Model. 82, 100

CRIC Consejo regional indígena del Cauca (Regional Indigenous Council of el Cauca). 28, 35

CTT Concur Task Trees. 6, 74, 76, 89

CUI Concrete User Interface. 89

DiaMODL Dialogue Modelling Language. 13, 83, 86, 87

FUI Final User Interface. 89

GOMS Goals, Operators, Methods and Selection rules. 6, 74, 75

HCI Human-computer interaction. 17, 19, 61, 62, 64, 65, 67, 69, 202

IBIS Issue-Based Information System. 101

ICT information and communication technology. 17, 19, 165, 197, 198, 200

IET Instituto educativo de Tumbichucue (Educational Institute of Tumbichucue). 34, 35, 135

KLM Keystroke-Level Model. 75

localization Adaptation of computer tools to a specific cultural context. 18, 110

MDA Model-driven architecture. 81, 200

MDE Model-driven engieneering. 81

MVC Model-View-Controller. 7, 78, 79

OMG Object Management Group. 90

PAC *Présentation-Abstraction-Contrôle*. 7, 78, 80, 205

PEBI Programa de educación bilingüe interculural (Intercultural Bilingual Education Program). 29, 34, 35, 135

PERCOMOM PERsonalization and COnceptual MOdeling Method. 90–92

PIM Platform Independent Model. 82

PSM Platform Specific Model. 82, 89, 100

QOC Question-Options-Criteria. 101–103, 201

resguardo Territorial unit inhabited by Colombian indigenous communities. Of communal and inalienable ownership, granted by the 1991 Colombian Political Constitution. 25, 27, 31, 35, 122, 125

RML Reference Model Language. 83, 100

TaskMODL Task Modelling Language. 83

thẽ' wala Nasa healer. 28

tul Nasa house garden. It is also a representation of the microcosmos. 137

tulpa Three-stones Nasa hearth. Associated with the center of family life and a place to meet close relationships. 25, 26, 122

UAN User Action Notation. 74

UEPM Usability Engineering Process Model. 19, 20

ũhza yafx Literally, mouse's eye. A significant rhombus shape symbol, having several meanings, including a vision of the world.. 32, 33

UsiXML User Interface eXtensible Markup Language. 7, 87

WIMP Windows Icons Menus Pointer. 91, 92

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Chapter 1

Introduction

The research questioning of this thesis is motivated by the sociocultural differences between information and communication technology (ICT) producers and users, and how such differences can influence the development and use of computer tools. In general, we can affirm that ICT has its origin mainly in industrialized societies, although the access to computer resources tend towards a worldwide sphere, reaching a wide diversity of cultural backgrounds. Hence, it is not surprising to find computers, and sometimes to count with an internet connection in the schools of the Nasa Amerindian people[1], a rural society that mainly inhabits the southwestern Colombian mountains. Given the users' cultural particularities, developing appropriate design and adapting computer tools to the sociocultural context is necessary. Thus, we aim at providing epistemological tools to help designers with the design of sociocultural-aware computer tools. In this work, we focused on the Nasa people. As we will show here, the contributions relate computer technology to efforts carried out by the Nasa people to revitalize their mother tongue through education.

Research about the users cultural diversity and how it is considered in computer tools and Human-computer interaction (HCI) has given important outcomes mainly in the last two decades. In 1996, del Galdo and Nielsen compiled different HCI and culture-related research works, including, among others: overviews of the impact of culture on user-interface design (Ito and Nakakoji, 1996, del Galdo, 1996), an account on cultural modeling as a tool to study the users' context (Hoft, 1996) and a description of issues and proposed solutions regarding Mandarin-language text edition (Jin and Chen, 1996). Del Galdo and

[1] The Nasa are also known as Paez or Páez, according to the name given by the Spanish. Here, we prefer to use the name they use when referring to themselves.

Nielsen classified the localization[2] of computer tools in three levels, according to the visibility of the cultural variables taken into account and their capacity to respect the users' cultural context. Del Galdo and Nielsen also identified the necessity to extend the cultural aspects considered in localization processes existing at that moment to reduce the negative impact of exogenous technology in users' societies: "The thought that technology may force users to lose their language or to make detrimental changes to their culture is contrary to the goals of the user-interface designer" (del Galdo and Nielsen, 1996, p. vii).

Advances are meaningful in different aspects of culture. Text representation and handling have evolved from the early 8-bit character encoding to the current Unicode standard (The Unicode Consortium, 2012), which has the capability to represent any grapheme from any human script. Furthermore, Unicode also covers other aspects related to graphic representation, such as: how to format dates, times and numbers, and how to display text according its directionality.

We can also find important works with respect to the consideration of other cultural factors, to cite a few of them: Lee (2001), Medhi et al. (2006), Winschiers-Theophilus (2009), Kam et al. (2009), Irani et al. (2010), Gorman et al. (2011), among an increasing number of examples. These works demonstrate that the impact of culture is ubiquitous in information and communication technology, from the design of the user interface until the evaluation methods and quality criteria, including information security and privacy aspects. From these works we can conclude that we cannot make assumptions about the relation between the users and the machines. This is particularly difficult because, as Winschiers-Theophilus (2009) states, intrinsic cultural values of developers permeate to all stages of the development cycle.

In this sense, it is worth to highlight the work of Irani et al. (2010), who propose an analytical approach to understand the challenges in what the authors call intercultural encounters in design practices. This represents a shift from the development efforts for "others" to a more engaging and participating discourse in the production of computer tools. In their orientation, Irani et al. consider the dynamic and collectively produced character of culture, taking into consideration in their discourse questions regarding the power, authority, legitimacy, participation and intelligibility within the encounters. Their contribution can be summarized in an alternate formulation of design work, consisting of engagement, articulation and translation. Engagement refers to connecting with the user to understand relevant work. The articulation means to comprehend how properties of the domain are formalized and transformed into a series of

[2] Localization and internationalization are terms referring to the adaptation of software to cultural contexts. Internationalization (i18n) stands for designing software so it can be adapted to different languages and cultural contexts. Localization (L10n) is the process of adapting internationalized software to the language and other variables of a specific context.

requirements for technological support. And the translation regards how these requirements are transformed from statements about the domain to statements about technology and tools to support the application domain. The most important conclusion that we can gather from their work is how the users context embeds the whole production process.

In the scope of the Nasa people, this thesis continues the previous work of Checa Hurtado and Ruano Rincón (2006), who, through an unsuccessful effort to translate the main computer interface into the Nasa language, found some HCI and Nasa culture-related issues. For example: (1) Nasa regular computer users were unaware of the Desktop metaphor and (2) the lack of full support for writing in the Nasa language with keyboards available in Colombia. One of the outcomes of that work was the identification of a social problem and a computer tool aiming at providing help to solve it: the diminishing use of the users' mother tongue –Nasa Yuwe– in favor of Castilian.

Checa Hurtado and Ruano Rincón accomplished a design procedure following the Usability Engineering Design Process (Granollers, 2003), which suggests to carry out ethnographic investigation during the initial stages of the development cycle. However, being an abstract process model, Usability Engineering Process Model (UEPM) does not provide any concrete ethnographic tool to study the culture. This need of a theoretical tool and the issues found in their work help us to shape the research questioning of this thesis. We can conclude that a theoretical mechanism to observe and study the user's sociocultural context was needed.

Moreover, the design process carried out was done without a formal modeling support, which makes it difficult to accurately use the design solutions in other developments. In other words, that work lacks a formal description method to inform other ICT producers how the authors solved the design issues they faced. Thereupon, this thesis focuses on two research questions:

1. *What should we study about the users sociocultural context if we need to develop pedagogical computer tools?* and
2. *How to describe the influence of the users' culture on interactive system design?*

The first question aims to provide ICT producers with a sound theoretical base to abstract, from the users sociocultural context, characteristics relevant to HCI. The goal of the second question is to integrate such consequences in approaches to describe computer tool designs, to give to other producers reusable information regarding how to solve a culture-related issue.

To answer these questions, we have selected a theoretical support consisting of: (1) existing cultural models, (2) semiotics in HCI, (3) interactive tool design models and (4) design knowledge description methods. This theoretical support has been partly selected according to the conclusions we gather from the preliminary work of Checa Hurtado and Ruano Rincón. As stated before, the ethnographic work exposed that a concrete tool to characterize the culture was lacking, and the research on cultural models would help to fulfill this need. The authors also observed issues in the interpretation of interface signs. However, they did not count with a conceptual base to understand the reasons behind. In this sense, semiotics would provide the tools to comprehend the differences that the users' culture provoke in the use of computer devices and in the understanding of the elements that make possible the interaction. Finally, the design products were developed according to the UEPM, following a process centered on the user, although they were done without a formal modeling support. Research on interactive system models and design description methods would contribute to produce an approach to formally describe the design experience and record how culture as influenced it.

Therefore, this thesis provides two major contributions thanks to this support:

1. A five-dimension **sociocultural context modeling approach** aimed to help with the study of the users' culture to design pedagogical tools. And consequently,
2. an **approach to describe design issues-solutions related to culture**.

These contributions are applied to the Nasa society and validated through the design concept of two different computer tools: a pedagogical game and a cooperative learning platform.

This manuscript describes this work through the following structure: after this introduction, Chapter 2 describes the Nasa society, drawing the main characteristics we have considered and introduces the two Nasa schools of the communities concerned: Tumbichucue and Caldono.

The next four chapters give an account of the state of the art of the theoretical support. After defining what is culture and what is a model, Chapter 3, describes existing well-known cultural models, which will compose the base to elaborate our first contribution. Chapter 4 gives a brief summary with respect to essential semiotics concepts, constituting an important tool to understand the research questioning of this thesis as a culture-related problem. Chapters 5 and 6 aim at studying different methods to describe a design solution, and will mainly support the second contribution. On the one hand, Chapter 5 is dedicated to interactive system modeling approaches. On the other hand, the 6th chapter explores complementary methods —Design Patterns and Design Rationale— to provide information regarding the design process and how it solves a specific issue.

The second part of the document is aimed at describing the contributions of this work. In Chapter 7 we draw the five dimensions of the cultural model that we propose, and its application to understand the Nasa culture. This chapter will also formulate two different types of hypothesis: a general work hypothesis, and a set of Nasa-specific design hypothesis. This latter will provide support to confirm or refute the general hypothesis. Chapter 8 is devoted to the in-field work in two considered Nasa communities, where it was possible to evaluate the two design concepts cited above. Chapter 9 provides a summary of our approach to describe culture-related design issues-solutions. These issues-solutions are expressed in such a way that other developers can make use of previously acquired knowledge regarding the users' culture.

Before continuing with the development of this manuscript we would like to state an unmeasurable aim: *minimize the possible unwanted impact of exogenous technology in users' societies*. In other words, we might to create design choices for people that accurately align with their own culture.

Ito and Nakakoji (1996) and del Galdo (1996) illustrate a notorious example of the negative influence of foreign technology in other cultures. These authors described that when "Western" word processors were introduced in Japan, several aspects of the Japanese writing system were unconsidered. To cite some of them: the writing directionality, the text formating in squared grids, text measuring among other unsupported characteristics. Consequently the Japanese writing system suffered different transformations, provoked by the use of this foreign tool, designed over the typewriter machine metaphor. Through this thesis, we aim to minimize this kind of issues in our users' context.

Chapter 2

Context of the study: the Nasa society

This chapter briefly describes the Nasa people, the community concerned within this thesis. *Why the Nasa?* The interest in the Nasa people arises from the author's previous work (Checa Hurtado and Ruano Rincón, 2006), that, as we have said before, unveiled culture-related issues in the development and use of computer technology. The main outcomes of that work were eighteen informally described guidelines regarding the development of computer tools in the Nasa context. These guidelines resulted from the design of *çut pwese'je*, a Nasa computer adaptation of the hangman game, which is illustrated at Ruano Rincón et al. (2010)[1]. Here, we will extend the scope of the previous work, and we will focus on larger Nasa sociocultural aspects, which will be studied on a more formal approach.

In this chapter we give a general outline of the geographical, economic and social situation of the Nasa people. Moreover, given the thesis' focus on educational tools, we pay special attention to education policies and we will provide a short overview of application context. A more detailed account regarding our target public will be given through the manuscript, mainly in Chapters 7 and 8.

It is important to say that our research on the Nasa culture has been carried out with the help of bibliographic material and the kind academic support from Universidad del Cauca Professor Tulio Rojas Curieux [2] and Nasa linguist

[1] *Çut pwese'je* consists of preventing a maize field from disappearing. To do this, the player must guess, letter-by-letter, a Nasa Yuwe hidden word, in a dynamic similar to *hangman*.

[2] Rojas Curieux, Tulio: Professor at the Universidad del Cauca and head of the Grupo de estudios, lingüísticos pedagógicos y socioculturales. Linguist expert in the Nasa language, who

Abelardo Ramos Pacho[3].

2.1 Geographical situation and territory

Figure 2.1: The Colombian territory. Approximative geographical position of the Nasa people circled in red[4].

We would like to introduce the Nasa people first by indicating their geographical situation. The Nasa are a mainly rural society, present in, at least, seven Southwestern departments of Colombia. However, the Nasa population is mainly established in el Cauca, in communities spread over both western and eastern slopes of the Central Andes mountain range (See Figure 2.1). As we

has been working with the Nasa people for more than 30 years.

[3]Ramos Pacho, Abelardo: Nasa linguist, considered a *mayor* (an elder and wise authority.) in the Nasa community.

[4]Based on the Image found at `http://commons.wikimedia.org/wiki/File:Colombia-deps-cauca.svg` (Under license CC-BY-SA-3.0. Accessed on November 28th, 2011).

will further describe, we hypothesize that the different geographical access situations, between both slopes, condition cultural characteristics within the Nasa society, producing different education needs in heterogeneous schools.

Most of these communities inhabit *resguardos*[5], delimited lands whose communal and inalienable ownership is granted by the Colombian Political Constitution and national laws. Agriculture is the main economic activity and constitutes the livelihood of most of the Nasa people. Different kinds of crops, such as maize, coffee, potatoes, and sugar cane are produced thanks to the diversity of temperatures found in the Caucan mountains Rojas Curieux (2002), differing across *resguardos* and Nasa territories.

2.1.1 Housing and learning familiar spaces

Family houses are spread over the territory, in the middle of farming lands or next to unpaved roads. In 1996, Ximena Pachón described most of Nasa houses as consisting of a single rectangular space, built with adobe walls and a thatched roof. In this single room, the sleeping and living areas are placed around the three-stone hearth, called *tulpa* (Pachón C., 1996). According to Lasso Sambony and Calambás Sánchez (2005), since the mid-90's new materials and structures have been introduced in an effort to improve the Nasa people's quality of life. Now, it is common to find houses with private and independent rooms, built with brick walls and tiles or corrugated iron roofs. Personal observations in the *resguardos* of Tumbichucue and Caldono in 2010 confirm that, in some cases, some two-storey houses were built as well.

Despite this transformation, the *tulpa* (Nasa three-stone hearth) keeps a meaningful and prevailing place in both old and modern houses. Lasso Sambony and Calambás Sánchez (2005, p. 23) affirm that the kitchen is the ideal place to give advice, share with other people, and learn. Even if the *tulpa* is being replaced by brick-made constructions, gas stoves or more modern equipment, the kitchen preserves its essential place at the center of the family and of community life. The three-stones *tulpa* is still used in communal work parties, as the hearth shown in Figure 2.2.

Lasso Sambony and Calambás Sánchez (2005, p. 77) also affirm that the *tulpa*'s three stones represent three members of a family: mother, father and child. Symbolizing the kitchen and the place for dining, the *tulpa* is the ideal space for inter-generational knowledge transmission. It is also a symbol of

[5] *Resguaros:* Communal and inalienable indigenous lands. The *resguardo* is the territorial unit that allows collective ownership over traditional lands by native communities. They are administered by elected councils (*cabildo*s) and legitimized by colonial titles (Rappaport, 2005).

Figure 2.2: Tulpa (three-stone hearth) used during a communal party in the school of San Andrés de Pisimbalá (2010)

identity with the territory. The custom of burying the newborns' placenta next to the *tulpa* (Rappaport, 2005, p. 149) is an index of the relevance given to this space[6].

Another important familiar space is the *tul*, the Nasa house garden, specialized in medicinal plants. According to Rappaport (2005), the *tul* is also a representation of the cosmos, an agricultural technological model and its presence next to or surrounding the house is essential in order to preserve the harmony with nature. As we describe later, the *tul* is ubiquitous the Nasa schools' curriculum.

Contextual Consideration 2.1. *The kitchen, and more precisely, the three-stone hearth called tulpa, is the basic familiar space for teaching and learning.*

2.2 Social organizations and education authorities

In the Nasa society, the *tulpa* also has an important place on social organization. Rappaport (2005, p. 149) quotes Mincho Ramos, Nasa leader and teacher, who states that the *tulpa* is the center of the social interaction levels,

[6] According to the National Geographic Magazine, July 2002, Vol. 222, No. 1, pag. 87, the Seri Mexican native people has a similar custom. For the Seri, the question "where is your placenta buried?" also refers to ask "where are you from?"

which can be drawn through a spiral analogy: The social interaction levels start at the *tulpa*, where the family meets and interacts, enclosed by the *tul*, which protects the house. They are surrounded by agricultural fields, and in turn, by the *resguardo*, the municipality, the department, and so on (Rappaport, 2005, p. 149).

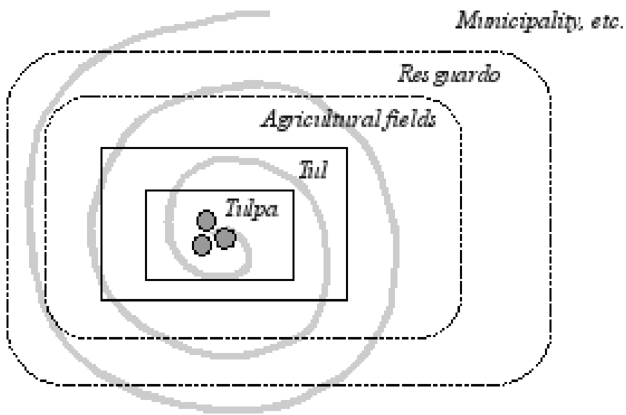


Figure 2.3: Graphical representation of the Nasa social interaction levels, according to the description made by Mincho Ramos

Contextual Consideration 2.2. *Moreover its domestic function, the tulpa is also the center of the social interaction levels, which can be represented by a expanding spiral.*

2.2.1 *El cabildo* and authority institutions

In the Nasa culture, we can identify different authority institutions, among others: the *cabildo*, the *capitán* and the *mayores*.

As we have said before, the *resguardos* are the main Nasa territorial units. Each *resguardo* is governed and administered by an elected council called *cabildo*[7], a hierarchical structure, currently composed of the *gobernador* (main authority in the community) and other lower-rank roles, such as: *comisario*, *alcalde* and *fiscal*.

As a symbol of authority, each *cabildante* carries a *vara de mando* (also called *bastón de mando*), a black-wooden lead staff. These staffs are given

[7]Or *nehwe'sx* in Nasa Yuwe, according to the document *Plan de vida de la comunidad del resguardo indígena de Tumbichucue.* (n.d)

to the *cabildo* by the mayor of the municipality where the *resguardo* is circumscribed, and *refreshed* by *thẽ' wala*s (Nasa healers) during a ritual in high-mountain lakes (Pachón C., 1996) (See Figure 2.4). All community members have several duties at the *resguardo*, such as the participation in collective works or assuming roles within the *cabildo*. Just the fact of never having served as *cabildante* is sufficient to be nominated in the next elections. Pachón C. (1996) also identifies the *capitán* as a parallel authority. It is an inherited role, similar to the *cacique* in other cultures, and a trace of ancient political systems.

It is common to find a group of *mayores*[8], composed of the *resguardo*'s eldest people (men and women) that have served as *goberandor*. According to Pachón C. (1996), this is an informal group that, given their knowledge regarding the *resgaurdo* and the Nasa culture in general, exerts their authority when the *gobernador* or the *cabildo* do not accomplish their functions according to what it is established.

Contextual Consideration 2.3. *The cabildo is the main resguardo authority. It is a council in which the highest-level role is the gobernador. Among its functions, the cabildo is responsible for organizing the collective work and administering resguardo resources.*

2.2.2 CRIC and other pan-cultural organizations

Pachón C. (1996) describes pan-cultural organization embracing *resguardos* and their *cabildos*, such as Consejo regional indígena del Cauca (Regional Indigenous Council of el Cauca) (CRIC) and the "Solidarios". These organizations aim to construct representative institutions of the *cabildos* in the region. *CRIC* was founded in 1971 with the main goal of recovering ancients lands, but has increased its areas of responsability, for example: strengthening economic communal organizations, ecological preservation in *resguardos* and the elaboration of production programs in recovered lands. According to the document Plan de vida de Tumbichucue, the CRIC's goals are: (1) recover ancient lands, (2) non-payment of tenant farming, (3) expand *resguardos*, (4) strength the *cabildo* and Nasa forms of authority, (5) ensure that indigenous-related laws are upheld, (6) defend Nasa history, mother language and customs, (7) train bilingual teachers, (8) set up economic organization aiming at communities strengthening, (9) protect natural resources and (10) strength the family as the community's axis.

[8] Not to be confused with the English-language "mayor". Here *mayor* refers to a generally elder person, considered an authority.

We are not going into further details regarding these goals. Nevertheless, in the context of our work, it is important to highlight that there is an explicit orientation to preserve the Nasa customs, including their political and authority institutions, as well as their mother language.

Figure 2.4: School *cabildo* “refreshing” the staffs of command. Taken from Institución Educativa Tumbichucue (2006)

The education organization authority. CRIC also manages education in communal schools, through the Programa de educación bilingüe interculural (Intercultural Bilingual Education Program) (PEBI). This Program aims to offer bilingual education, in Nasa Yuwe and Castilian, covering elementary and secondary schools. The curriculum elaborated by the *PEBI* follows the community's traditions and practices, and it focuses on agricultural activities (Rappaport, 2005). *PEBI* was designed as a way to preserve culture and strengthen Nasa politics through education (Consejo Regional Indígena del Cauca - CRIC and Rappaport, 2004). Among these policies, we can find in each Nasa school a *cabildo* composed of students, which fulfills the same roles as the *cabildo mayor*, but in the schools' scope.

Contextual Consideration 2.4. *The Nasa authorities administer the education through the Intercultural Bilingual Education Program (PEBI). This program is in charge of training bilingual teachers and defining the school curriculum.*

Contextual Consideration 2.5. *There is a student cabildo in each Nasa education center. In schools, students learn to fulfill authority and administration roles.*

2.3 Work organization

One important characteristic of the Nasa people is the value given to cooperative work. As described by Pachón C. (1996) and Rojas Curieux (1996, p. 27), the Nasa people organize work based on "invitations to work" or "invitations to help", which can be classified in three types: (1) *Nmicambio* or Mano-cambio ("hand change") (2) *Pi'txya' nasa*[9] or peoples' invitation (3) *Khuẽeswe'sx pi'txnxi* or the *cabildo* invitations.

All of these are forms of cooperative work. However, *nmicambio* and *pi'txya' nasa* invitations are made by members of a household when they need, for example, to harvest the family's agricultural lands, while *khuẽeswe'sx pi'txnxi* invitations are organized by the *cabildo* and meet communal needs such as building a new class room or repairing roads. Each family living in the *resguardo* must take part in these activities. It is a Nasa duty to accept and participate in these collective works[10].

Contextual Consideration 2.6. *The Nasa place a high value on collective work. To take part in cooperative endeavours ratifies being part of the community.*

2.4 Nasa Yuwe, the Nasa language

Nasa Yuwe[11] is the Nasa people's mother tongue. It is categorized as an isolated language, without any demonstrable affiliation to other linguistic families. At present day, it is spoken by around 100,000 people, representing two thirds of the whole Nasa population. Nasa authorities consider it as an endangered language, and most education policies aim at increasing its use, especially among the young population.

We can drawn some partial numbers about the use of Nasa Yuwe through the project "Palabra y memoria en Novirao" (Word and memory in Novirao), Ro-

[9] Written according to the interview with Nasa teachers and students in Tumbichucue.

[10] In Colombia, the Spanish-language *minga* refers to these collective work parties. According to the *Diccionario de la lengua española* (), *minga* comes from Quechuan *mink'a*, and has been integrated in the Spanish-language variation of Colombia, Ecuador, Peru, Bolivia and North Argentina, with the same meaning. As a manner of hypothesis, we can formulate that there exist other Amerindian cultures whose work organization focus on cooperative activities. Nevertheless, we do not have detailled information about the extend of this kind of practices. This hypothesis can only be validated through a further analysis.

[11] Nasa: human being, people, living being. Yuwe: mouth, language

jas Curieux, T., M. Corrales, and A. Perdomo (2009). The authors interviewed the 78 families composing the *resguardo* of Novirao on the decreasing use of Nasa Yuwe[12]. Among the answers to the question: *Why do you believe that people in Novirao is not longer speaking in Nasa Yuwe?* 59 families affirmed "because (people) have not been taught (the language)", 53 families affirmed that the reason was "shame" of speaking in Nasa Yuwe, and fourteen said because of "the influence of technology."

Vowels:

Oral	i	e	a	u	Nasal	ĩ	ẽ	ã	ũ
Glottalized oral	i'	e'	a'	u'	Glottalized nasal	ĩ'	ẽ'	ã'	ũ'
Aspirated oral	ih	eh	ah	uh	Aspirated nasal	ĩh	ẽh	ãh	ũh
Long oral	ii	ee	aa	uu	Long nasal	ĩi	ẽe	ãa	ũu

Consonants:

	Bilabial	Alveolar	Palatal	Velar
Basic	p	t	ç	k
Aspirated	ph	th	çh	kh
Palatalized	px	tx	çx	kx
Palatalized aspirated	pxh	txh	çxh	kxh
Prenasalized	b	d	z	g
Palatalized prenasal	bx	dx	zx	gx
Nasal	m	n		
Palatalized nasal		nx		
Fricative		s		j
Palatalized fricative	fx	sx		jx
Lateral		l		
Palatalized lateral		lx		
Approximants	w		y	
Palatalized approximant	vx			

Table 2.1: The Nasa Yuwe alphabet

An important change faced by Nasa Yuwe has been the adoption of writing technology. The Nasa people was based on oral tradition. However, in 2001 the community agreed to the use of a unified alphabet for their language (Rojas Curieux, 2002). The Nasa Yuwe alphabet consists in 69 graphemes, with 32 are vowels and 37 consonants. There are two groups of vowels: oral (i, e, a, u) and nasal (ĩ, ẽ, ã, ũ) and a basic group of consonants: p, t, ç, k, m, n, b, d, z, g, l, s, j, y and w. (Rappaport (2005, p. xviii) also includes the r in a similar list). According to the phonetic process they represent, graphemes might be also digraphs or trigraphs. The vowels may be glottalized (-'), aspirated (-h) or long (the letter is doubled). Palatalized consonants are succeeded by x, aspirated by

[12]Personal communication with Rojas Curieux, T. and Corrales M. Popayán, Colombia, 2010.

h, and when both process occur simultaneously, both diacritics are used (-xh). This is shown more clearly in Table 2.1.

Contextual Consideration 2.7. *Nasa education policies aim at fortifying the use of Nasa Yuwe through bilingual education.*

Contextual Consideration 2.8. *The Nasa Yuwe alphabet consist of 69 graphemes, that can be monographs, digraphs or trigraphs.*

2.5 Aesthetic expressions and common symbols

Nasa artistic expression includes dances, music, a wide range of (woolen) fabrics and handcrafts, etc. Among the graphical representations elaborated by the Nasa in these expressions, two symbols prevail and are ubiquitous: the spiral and *ũhza yafx* (a rhombus-shape symbol). Figure 2.5 shows an example of the rhombus in handcrafts. We focus particular interest on these representations as possible communication elements in the interface.

Figure 2.5: Rhombus sequences use to compose handcrafted bag straps. Image taken from Lasso Sambony and Calambás Sánchez (2005, p. 79)

The ũhza yafx: According to Lasso Sambony and Calambás Sánchez (2005, p. 109), *ũhza yafx*, the rhombus-shape symbol, is associated with several meanings in the Nasa culture. First, the Nasa spiritual organization. View from its structure, the *ũhza yafx*'s four corner shape represents the four main energies –water, air, fire and earth. These energies are required in order to preserve the equilibrium and harmony in the life of the Nasa people. Second, *ũhza yafx* literally means "mouse's eye". When the rhombus is represented with a point at the center, it is associated with protection and cleverness, honoring the mouse's escaping skills. Third, it also symbolizes the woman's body, especially the abdomen, as the birthplace of life.

Figure 2.6: Calendar elaborated by three Tumbichucue school students Jesús Aníbal Dinó Pesay, Jhon Ramos Usnas and Fánor Pame Díaz.

The spiral: On the other hand, Lasso Sambony and Calambás Sánchez (2005, p. 43) argue that the spiral represents life, evolution, knowledge, among other concepts, such as time, which is seen in the Nasa culture as a right-to-left spiral, as shown in the calendar drawn by three Tumbichucue students (See Figure 2.6). Moreover, as described before, the spiral is also related with the Nasa social interaction spaces. Summarizing, the spiral is a symbol of evolution, knowledge and territorial expansion in the Nasa culture.

2.6 Application and research context

Since the thesis' scope is the development of pedagogical computer tools, we must take into account the education needs of the target users. As described in this section, Nasa education focus is centered on agriculture and the revitalization of language and culture.

The thesis contributions will be evaluated through the design process of two pedagogical computer applications. In their evaluation, two Nasa PEBI schools, locate at different slopes of the mountains were concerned: the Instituto educativo de Tumbichucue (Educational Institute of Tumbichucue) (IET) and the Centro de formación integral comunitario (Communal Integral Education Center) (CEFIC). These schools will be described with more detail in Chapter 8.

As previously stated, this thesis takes into account the work of Checa Hurtado and Ruano Rincón. It is important to note that the initial reason to carry out research work on computer tool design with the Nasa was the hypothesis that the Castilian interface made impossible for the Nasa to use computers. The linguistic perspective of this issue suggested the need of support from the social sciences. Checa Hurtado and Ruano Rincón looked for the help of Tulio Rojas Curieux and Abelardo Ramos Pacho, academic experts well known by the Nasa community. They have been working with the Nasa for more than thirty years, have participated in the unification of the alphabet and in the translation of the Colombian Constitution into Nasa Yuwe. Moreover their academic contribution, they contacted the Nasa authorities, exposed the ideas, goals and plans and asked for the authorization to carry out the research work, including this thesis.

During the field work, Abelardo Ramos accompanied the author in the first visits to Tumbichucue and Caldono to introduce him to the local authorities, teachers and students. Despite most of the work was done in Castilian, Ramos also served as Spanish-Nasa Yuwe translator during the design evaluation activities.

It is also worth to note that during the stay in the *resguardo* of Tumbichucue, the author took part in the regular collective work activities, organized by the *cabildo* (*khuẽeswe'sx pi'txnxi*, see Section 2.3). We can hypothesize that this participation eased the approval to carry out the design and evaluation processes of the tools and the collaboration with the concerned users.

2.7 Summary

In this chapter we have drawn general characteristics of the Nasa society, such as, their geographical location, economic and livelihood activities oriented towards agriculture. We have shown how communities share their lands, under socio-political territorial units called *resguardo*s. We have also described the main Nasa authority institutions, including the *cabildo*, which is in charge of administer and govern each *resguardo*. It is important to note that children in schools learn to take part in these institutions, composing a *student cabildo* in each school.

*Resguardo*s and *cabildos* are grouped in regional pan-cultural organizations such as CRIC and its PEBI, that is in charge of the education in schools. PEBI adapts the Colombian education base to focus on agricultural activities and bilingual education. Education is a political tool that aim at strengthening the use of Nasa Yuwe, the Nasa mother language.

We have given some insights regarding the work organization, such as the high value given to cooperative work and their different forms. To take part in collective tasks is an important act to reaffirm being part of the community.

We have also provide a brief summary of Instituto educativo de Tumbichucue (Educational Institute of Tumbichucue) (IET) and Centro de formación integral comunitario (Communal Integral Education Center) (CEFIC), the two schools concerned in this thesis. Despite the fact that both are Nasa schools administered by the PEBI, IET and CEFIC present important differences in the use of Nasa Yuwe. We hypothesize that these differences arise given the respective contact situation with the industrialized Castilian-speaking prevailing society.

We can conclude that our goal is to take into account a wide range of sociocultural aspects in the design of computer tools, that we can consider through the following questions:

What are the consequences of writing system, literacy degree and other users' language characteristics on pedagogical tool design?

How the work organizations, authority institutions, education policies and other social organization aspects influence system requirements?

How the aesthetic expressions determine interface characteristics?

What computer resources would support new tools? Who would give technical support one the tools have been deployed?

Is it possible to create interface metaphors according to the users' environment?

What cultural elements could be taken into account to structure the interface?

Part I

State of the art/Theoretical support

Chapter 3

Cultural Models

Cultural research methods have a central place if we need to answer the question: "*What should we study about the users sociocultural context if we need to develop pedagogical computer tools?*" A similar questioning is found in the work of Hoft (1996), who suggests that to model the users' culture helps to abstract characteristics related to the design of computer tools. According to Hoft, a cultural model makes it possible to understand the culture, acquire relevant data, and use it in the design process.

Hoft does not propose a universal or generic cultural model, she rather provides tools –meta-models and examples of existing models– to help computer tools developers to elaborate a specific model for each cultural context and development need. We have followed Hoft's suggestion and studied existing well-tested cultural models, to select from them cultural characteristics with possible consequences on the development and the use of computer devices.

It is important to highlight that these models and the characteristics that we abstract from them (detailed in Chapter 7) are delimited within a specific frame, responding to particular needs. As we state here, these models are limited representations of the users' culture, and the knowledge they make possible to gather is partial and situated in the development context where they are applied. Before going further, we need to define two concepts: culture and model.

3.1 What is culture?

Similarly to the object it refers, we can find a wide variety of definitions of what culture is. To give some numbers, in 1954, Kroeber and Kluckhohn have reviewed more than 300 definitions of culture[1] and we can suppose the number is higher at present day. Among the definition available, we present here those that we consider important to construct our cultural model.

In the Standard dictionary of social sciences (Koschnick, 1992, p. 700-702) compiles different definitions from social sciences researchers, including Taylor and Wolfgang, among others.

For Edward Taylor culture is a synonym of civilization, differing from what he calls the "lower tribes": "in its wide ethnographic sense, (culture or civilization) is a complex whole which includes knowledge, belief, arts, morals, law, custom, and any other capabilities and habits acquired by man as a member of society." Wolfgang gives culture a larger scope: "At the simplest level, culture is everything learned and shared by people. It is not simply a knowledge of the arts or the social graces, but includes the profane as well as the sublime, the secular as well as the sacred. Language is a part of culture. The attitudes ... that affect peoples actions toward others are part of culture. Sex roles and religious beliefs are part of culture."

Hall (1990, p. 183), whose work will be concisely presented here, identifies the human exclusivity of culture: "Culture is a technical term used by anthropologists to refer to a system for creating, sending, storing, and processing information developed by human beings, which differentiates them from other life forms. The terms *mores*, *tradition*, *custom*, and *habit* are subsumed under the cultural umbrella."

Hofstede (2005), who has also proposed a cultural model taken into account here, compared culture as the way how computer are programmed. Hofstede considered culture as "collective programming of the mind" (p. 5):

> "Every person carries within him or herself patterns of thinking, feeling, and potential acting which were learned throughout their lifetime...
>
> Using the analogy of the way in which computers are programmed, such patterns of thinking, feeling, and acting *mental programs, or ... "software of the mind"...* Mental programs vary as much as the social environment in which they were acquired ...

[1] As cited by Hoft (1996, p. 71)

> Culture is always a collective phenomenon, because it is at least partly shared with people who live or lived within the same social environment, which is where it is learned. It is the *collective programming of the mind which distinguishes the members of one group of category of people from another.*"

Despite their differences, we can find a common characteristic in these definitions:

Theoretical Consideration 3.1. *Culture is learned and shared.*

As we will show here, Hoft (1996, p. 41) chooses a definition of culture aimed to develop cultural models: "culture is, after all, learned behavior consisting of thoughts, feelings, and actions." Hoft's definition does not explicitly consider the shared aspect of culture.

Since the research questioning of the thesis is also related to signification and representation, it is important to take into consideration the concept of culture in semiotics theories. According to Eco (1976, p. 22) culture has an essential role in communicative and signification processes: "the whole of culture *should* be studied as a communicative phenomenon based on signification systems." In the same semiotics context, de Souza (2005, p. 100) affirms: "The role of culture in human communication is to function as a container of signs and meanings that "cohere in predictable ways into patterns of representation which individuals and groups can utilize to make or exchange messages" (Danesi and Perron, 1999, p. 67)." Thus, the function of culture in signification process has to be considered in our model.

On the other hand, we can also take into account how the Nasa people defines culture. This concept can be back-translated into Spanish from the translation of the Colombia Political Constitution into Nasa Yuwe: culture is "(la) forma de comportamiento que resulta de la permanencia en relación armónica con la naturaleza" or "the form of behavior resulting in a permanently harmonic relationship with nature" As cited and translated into English by (Rappaport, 2005, p. 95)

We could hardly find a consensus regarding what the concept of culture is. Nevertheless, we can select a definition that covers our research questioning. Therefore, from our point of view, the concept of *culture* is *learned* and *shared* and it concerns signification, behavior and feeling systems, that would influence the users' perception regarding computer tools. Summarizing, we can define culture as follows.

Definition 3.1. *Culture is collectively learned system of significations and behavior, consisting of thoughts, feelings and actions.*

3.2 Defining a cultural model

From our point of view, a model is a representation of a reality. We can find a clear and precise definition in this sense in the Merriam-Webster dictionary: *"11: a description or analogy used to help visualize something (as an atom) that cannot be directly observed."*[2] Similar to atoms, *cultures* cannot be directly perceived, still, we need to study them. As claimed by Hoft, modeling can be a suitable tool to observe the users' culture and gather relevant information.

It is important to note that the modeling process depends on the observer's context, needs, background, purpose, among other factors. This explains the diversity of existing models in a wide range of disciplines: mathematical, architectonic, biological, physical, climatological, etc. Let us consider two other definitions of *model*, the first in the *Lexique des sciences sociales*, Grawitz (1994, p. 269)[3]:

> "(***Math.***) Représentation théorique formelle et simplifiée d'une réalité complexe, traduite généralement en langage mathématique. . . . (***Sc. po. Socio. Anth***) L'absence d'unité quantifiée, la multiplicité des variables qualitatives rendent la construction de modèles délicate mais toutes les sciences sociales en cherchent."

And another definition from the Merriam-Webster's dictionary:

> "12 : a system of postulates, data, and inferences presented as a mathematical description of an entity or state of affairs;"

According to these definitions, mathematical models aim to give a formal representation to complex realities. However, Grawitz claims that, for Social Sciences, it is difficult to mathematically construct models, due to the lack of

[2] `http://www.merriam-webster.com/dictionary/model` Accessed on August 14th, 2012

[3] Our translation: (**Math.**) Formal and simplified theoretical representation of a complex reality, generally mathematically expressed. . . . (**Political science, Sociology, Anthropology**) The social sciences seek to construct models, although the lack of a quantified unit and the multiplicity of qualitative variables that make difficult the model construction.

quantified information and the abundance of qualitative data. We need to consider these characteristic of the social studies if we need to model the different characteristics of the user's culture, and that will establish the limits of our representation.

If we agree to Definition 3.1, we can formulate delineate the definition of cultural model, in the context of our work, as follows:

Definition 3.2. *A cultural model is a qualitative representation of the group's learned and shared system of significations and common behaviors.*

However, we must consider that this representation is situated and limited to context of our work. In other words, for us, to model the culture means to delimit, characterize, comprehend the user's sociocultural characteristics related to the development of computer tools, and compare how those characteristics differ from ours.

In the following section we give a brief summary with respect to the culture-related research works that were considered in this thesis to construct a cultural model, and subsequently, characterize the Nasa culture. We have divided these models in two categories, according to their main focus: (1) *value systems and problem solving* and (2) *intercultural communication*.

3.3 Human problem solving and Value system models

We have classified three different cultural model works in this category: Kluckhohn and Strodtbeck, Hoftstede and Trompenaars.

3.3.1 Florence Kluckhohn and Fred Strodtbeck

Anthropologists Florence Kluckhohn and Fred Strodtbeck studied the fundamental value systems of human beings and the influences of those values over behavior. Kluckhohn and Strodbeck aimed to conceive a theory on variations in value orientation and a method designed for cross-cultural evaluation.

According to their theory, *value orientations* are related to the way how a group of people solves common problems, and are defined as: "complex but definitely patterned (rank-ordered) principles, resulting from the transactional interplay of three analytically distinguishable elements of the evaluative process–the cognitive, the affective, and the directive elements–which give order and direction to the ever-flowing stream of human acts and thoughts as these relate to the solution of *common human problems* (Kluckhohn and Strodtbeck, 1961, p. 4)."

Their value oriented characterization is the result of extensive field research in the U.S. American southwest, between 1950 and 1951. They observed and interviewed local cultural groups including Latin Americans, Texans, Zuni and Navaho. In their study, Kluckhohn and Strodtbeck study and classified value orientations according to three main assumptions: (1) There is a limited number of common human problems for which all people at all times must find some solution. (2) While there is variability in solutions of all problems, it is neither limitless nor random but is definitely variable within a range of possible solutions. And the assumption that provides the main key to the analysis in variations in value orientations: (3) All alternative of solutions are present in all societies at all times but differently preferred.

According to these assumptions, Kluckhohn and Strodtbeck (1961, p. 11) identified five common "human problems", introduced in the form of questions:

- "What is the character of innate human nature?"
- "What is the relation of man to nature (and supernature)?"
- "What is the temporal focus of human life?"
- "What is the modality of human activity?"
- "What is the modality of man's relationship to other men?"

From these questions, Kluckhohn and Strodtbeck formulated five orientations, that we briefly present in the rest of the section: *human nature orientation*, *man nature orientation*, *time orientation*, *activity orientation* and *relational orientation*.

Human Nature Orientation This orientation refers to the innate goodness or badness of human nature, which can be divided in Good, Good-and-Evil, and Evil. According to Kluckhohn and Strodtbeck, people of some cultures, like the U.S. American, believe that the human being is innately Evil. Constant control and discipline of the self are needed to achieve any real goodness, where regression is always a risk. Other cultures conceive human nature as a mixture of

Orientation	Range of Variations					
Human Nature	Evil		Neutral	Mixture of Good and Evil	Good	
	Mutable	Immutable	Mutable	Immutable	Mutable	Immutable
Man Nature	Subjugation to Nature		Harmony with Nature		Mastery over Nature	
Time	Past		Present		Future	
Activity	Being		Being in Becoming		Doing	
Relational	Lineality		Collaterality		Individualism	

Table 3.1: Value orientations and their variables. Based on the Table "The Five Value Orientations and the Range of Variations Postulated for Each" (Kluckhohn and Strodtbeck, 1961, p. 12)

Good-and-Evil. And the last classification, however not yet observed, are cultures for which human nature is immutably Good(Kluckhohn and Strodtbeck, 1961, p. 11).

Man-Nature (Supernature) Orientation [4] This orientation answers the question "can nature be conquered or not?" It has three possible categories: *Subjugation to Nature*, *Harmony with Nature* and *Mastery over Nature*.

Sheepherders of the southwestern countries of America provide the typical example of *Subjugation to Nature*. They firmly believe that there is not much a human being can do to protect land when damaging storms descend upon them. They just accept it as something that is inevitable. *Harmony-with-Nature* cultures do not present a real separation of human being, nature and supernature. One is the just an extension of the other and there is a concept of wholeness that emerges from this unity(Kluckhohn and Strodtbeck, 1961, p. 13). This kind of orientation seems to have been the prevailing one in many periods of Chinese history, and it is strongly evident in current and ancient Japan. Most people in the United States of America have an *Mastery-over-Nature* orientation. Natural forces of all kind are to be overcome and put to the use of human beings

Time Orientation This deals with the value that each culture gives to "Past", "Present" and "Future."

Past-oriented cultures show respect for elders and ancestors. Origins of family, nation or history in general are frequent subjects in conversations or public talks. The context of tradition or history is a common point of view. Asians cultures belong to this category(Kluckhohn and Strodtbeck, 1961, p. 13). *Present-oriented people* consider activities and enjoyment of the moment as the most important. Present relationships, here and now, have special interest for them. Future plans are not objected to but rarely executed. *Future-oriented*

[4]Kluckhohn and Strodtbeck (1961) refer to this orientation as "Man-Nature."

cultures are mostly interested in youth and future potentials. They frequently talk about aspirations, prospects, and future achievement.

Activity Orientation The fourth of the common human problems refers to the modality of human activity. This orientation is classified in *Being*, *Being-in-Becoming* and *Doing*(Kluckhohn and Strodtbeck, 1961, p. 15).

Being orientation cultures prefer the kind of activity corresponding to a spontaneous expression of what is conceived to be "given" in the human personality: "a release and indulgence of existing desires (Kluckhohn and Strodtbeck, 1961, p. 16)." The difference between this and the *Being-in-Becoming* orientation is that the latter presents the idea of human development as dominant value.

According to Kluckhohn and Strodtbeck (1961, p. 17), the *Doing* orientation is the characteristically dominant in the U.S. American society. This orientation can be distinguished by its "demand for the kind of *activity*, which results in accomplishments that are measurable by standards conceived to be external to the acting individual."

Relational Orientation The last of the common human problems is the value orientation in relationships between people. This is developed in three categories: *Lineal*, *Collateral* and *Individualistic*(Kluckhohn and Strodtbeck, 1961, p. 17).

In *individualistic* orientation cultures, individual goals are awarded more primacy than in *Lineal* and *Collateral* societies. The *collateral* orientation give more value to the goals and welfare of the laterally extended group. The problem of a "well-regulated continuity of group relationships through time is not highly critical." This is the main difference with the *Lineal* orientation, where one of the most important goals is the continuity of the group through time. This goal includes the ordered positional succession within the group.

Among the five human problems identified here, the relational orientation is maybe the most concerned with our thesis. Let us formulate the question: *What is the place of computer tools in individualistic, lineal or collateral human relationships and problem-solving styles?*

3.3.2 Geert Hofstede

Geert Hofstede developed a cultural model while he worked at IBM. He founded the Personnel Research Department of IBM Europe, and managed it between 1965 and 1971. During his work at IBM, Hofstede run an international exhaustive survey related with the employees' personal values to the work situation.The outcomes of that survey influenced him to run or refer other multinational surveys that validate the initial findings, which greatly influence the development of his cultural model, briefly described here.

Hofstede's model is composed of four variables: *Power Distance*, *Collectivism vs. Individualism*, *Femininity vs. Masculinity* and *Uncertainty Avoidance*. These variables help to identify differences in mental programming.

Power Distance: It measures how subordinates respond to power and authority. In other words, how subordinate people value inequality. Hofstede found that *high-power distances* are common in Latin American countries, France, Spain, Asia and Africa. In these countries, subordinates are usually afraid of their bosses, bosses tend not to confer with their subordinates, and bosses are commonly paternalistic or autocratic. United States of America, Great Britain, much of the rest of Europe, New Zealand and Israel are *Low-power-distance* countries. There, subordinates tend to challenge bosses, who commonly use a consultative management style.

Collectivism versus Individualism: These values describe the relationship between the individual and the society that predominates in a culture.

In *individualistic cultures* there is not much social cohesion. People are expected to look out for themselves. Countries that value individualism include USA, France, Germany and Canada. They have a strong emphasis on personal time, freedom and challenge.

In *collective cultures*, people develop important personal and protective ties. They are also "expected to provide unquestioning loyalty to the group during their lifetimes and sometimes beyond." Some strong values in this kind of societies include training, physical conditions and use of skills. Examples of countries where collectivism is highly valued are Japan, Costa Rica, Mexico, Korea and Greece.

Masculinity versus Feminity: According to Hofstede's survey, men and women at IBM had different work goals. This dimension refers to the assertion of whether biological differences between feminine and masculine genders should or should not have implications over their roles in activities. "The predominant value in this cultural variable, in many cases, is for men to be more assertive and for women to be more nurturing."

Uncertainty Avoidance: This variable refers to "the extent to which people feel threatened by uncertain or unknown situations." Hofstede characterizes this dimension as "what is different, is dangerous", and states that people in different subsidiaries in different countries have different levels of tolerance to uncertainty. This variable may be measured through the units *strong* and *weak*.

Strong uncertainty avoidance suggests that people in a culture tend to perceive unknown situations as threatening, and therefore, they try to avoid these situations. Hofstede indicates some characteristics of cultures that present this level of uncertainty avoidance: (1) uncertainty is a continuous threat that must be fought (2) there is acceptance of familiar risks, but fear of ambiguous situations and of unfamiliar risks (3) what is different is dangerous (4) teachers are expected to have all the answers (5) students are comfortable in structured learning situations and concerned with the right answers (6) there is suppression of deviant ideas and behavior and (7) there is a resistance to innovation, etc. Latin American countries, Japan and South Korea are examples of countries with strong uncertainty avoidance.

On the other hand, *weak uncertainty avoidance* cultures are less threatened by unknown situations, and their characteristics include: (1) Uncertainty is a normal feature of life (2) people feel comfortable with ambiguous situations and unfamiliar risks (3) what is different is curious (4) students are familiar with open-ended learning situations and concerned with good discussions (5) teachers may say "I don't know" (6) motivation is by achievement and esteem or belongingness (7) there is tolerance of deviant and innovative ideas Examples of countries where culture have *weak uncertainty avoidance* are the Netherlands, the United States, Singapore, Hong Kong and Great Britain.

3.3.3 Fons Trompenaars

According to Nancy Hoft, Fons Trompenaars studied under Geert Hofstede, so, there are similar artifacts used in both models. Although, their results are different. Trompenaars proposes a seven dimension model, which, like Hofstede's, is quantified through data from an extensive multinational survey.

Trompenaars (1993, p. 6) cites Schein (1985) to define cultures as "the way in which a group of people solves problems and reconciles dilemmas." Trompenaars affirms that every culture distinguishes itself from others by the specific solutions it chooses to certain problems which reveal themselves as dilemmas.

He categorizes three groups of problems within the seven dimensions of culture, which typify the solutions that cultures apply when people solve those problems:

1. Problems that arise from our relationships with other people
    (a) universalism versus particularism
    (b) individualism versus communitarianism
    (c) neutral versus emotional
    (d) specific versus diffuse
    (e) achievement versus ascription
2. Problems that come from the passage of time
    (a) attitudes to time
3. Problems related to the environment
    (a) attitudes to the environment

Universalism versus Particularism This is a rules versus relationships dimension. On the one hand, *universalism* is the rules-based approach: "what is good and right can be defined and always applies." In a pure state, *universalism* may be seen as the application of equality, in the sense that rules are the same for everyone, no matter the degree of relationship between people. Examples of countries with a high level of *universalism* are France, Switzerland, USA, Canada, Ireland and Sweden.

On the other hand, *particularists* are relationship-based, according to the exceptional nature of present circumstances. Examples of particularist countries are Venezuela, Nepal, South Korea, Russia and China.

Individualism versus Collectivism Trompenaars takes concepts from Parsons and Shils, who describe individualism as "a prime orientation to the self" and communitarianism as "a prime orientation to common goals and objectives" Parsons and Shils (1951).

This cultural variable refers to the way in which people perceive themselves, primarily as individuals or as members of a group. Trompennars focuses particularly on how the value orientation is applied within the working environment. He used questions like the following in the surveys to evaluate this dimension:

> "Two people were discussing ways in which individuals could improve quality of life.
>
> **A** One said: 'It is obvious that if individuals have as much freedom as possible and the maximum opportunity to develop themselves, the quality of their life will improve as a result.'
>
> **B** The other said: 'If individuals are continuously taking care of their fellow human beings the quality of life will improve for everyone, even if it obstructs individual freedom and individual development'.
>
> Which of the two ways of reasoning do you think is usually best, A or B? (Trompenaars, 1993, p. 50)"

The results showed Israel, Romania, Nigeria, Canada and USA as the countries with highest levels of Individualism. Countries with the lowest levels included Egypt, Nepal, Mexico, India and Japan.

Neutral or Emotional This dimension measures the range of emotions that people express in their relationships with others, specially in the business context. According to the results of Trompenaars' surveys, countries where it is acceptable to express emotions within business situations include Italy, the United States and France. On the other hand, countries where expressing those emotions is not accepted include Japan, United Kingdom and Norway.

Specific versus Diffuse This value orientation measures the degree of involvement that people have in other people's lives. *Specific-oriented cultures* present a clear division of business and private relationships, where "a good business relationship is often kept separate from a good friendship." The United States, Australia, the United Kingdom, the Netherlands and Sweden are example of countries where this kind of relationship is highly present.

Diffuse-oriented cultures do not have very much differentiation between public and private life, including business relationships. Private and public boundaries, spaces and relationships are diffuse. Examples of these kind of cultures are found in France, Mexico, China, Singapore and Japan.

Achievement versus Ascription This dimension refers to how people's status is accorded, by their achievements or by attributes like kinship, gender, age and educational record. In *achievement-oriented cultures*, status is accorded based on individual achievements. Examples of these cultures include Norway, the United States, Canada and the United Kingdom. While in *ascription-oriented cultures*, status of people is conceded by personal connections, kinship, gender, age, etc. In this category, we found Russia, Japan, Spain, France, China and Belgium.

Attitudes to Time Trompenaars explores different approaches to explain the concept of time, similar to Kluckhohn and Strodtbeck's work, who identified three types of culture: present-oriented, past-oriented and future-oriented.

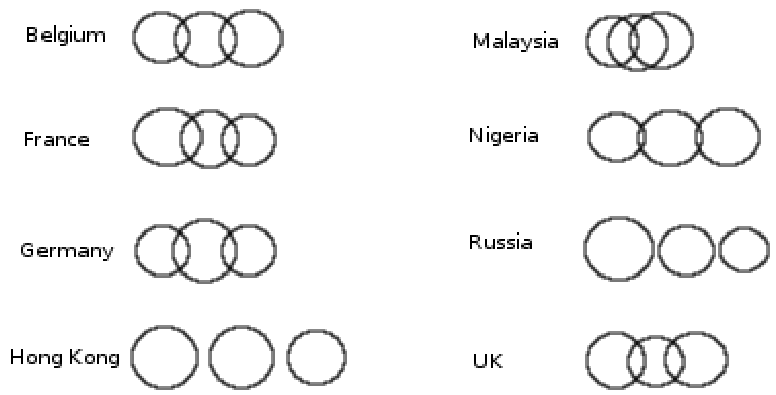


Figure 3.1: Past, present and future, represented by the Tom Cottle's "Circles Test" in Trompenaars' surveys. Taken from Trompenaars (1993, p. 127)

To measure orientations of time, Trompenaars used the methodology from Cottle (1967). One of the questions asked in the survey was based on his "Circle Test":

> "Think of the past, present and future as being in the shape of circles. Please draw three circles on the space available, representing past, present and future. Arrange these circles in any way you want that best shows how you fell about the relationship of the past, present and future. You may use different size circles. When you have finished, label each circle to show which one is the past, which one the present and which one the future (Trompenaars, 1993, p. 126)."

Attitudes to the Environment This variable, based on the work of J.B. Rotter[5], refers to the role that people assign to their environment. Trompenaars affirms that societies that conduct business may have two possible major orientations toward nature: they either believe that they can and should control it or they believe that human beings are part of nature and must accepts its laws, directions and forces. The first classification is described as *inner-directed*, the second, as *outer-directed*.

3.4 Intercultural communication and behavior

In this category we can find two important models developed by Edward Hall and David Victor.

3.4.1 Edward Hall

Edward Hall is a respected anthropologist who has carried out wide research on inter-cultural communication, whose theories have been widely used in various practical fields, such as design, architecture and business communication. Hall has not defined a delimited "model of culture", his work is registered in several books (Hall, 1966, 1976, 1989, 1990), which describe the different variables summarized in this section. The six cultural variables studied by Hall include: *contexting*, *speed of messages*, *space*, *time*, *information flow* and *action chains*.

Context Hall defines his idea of contexting as the amount of information transmitted and the amount of information stored or assumed when a communication takes places. He proposes two types of contexting: *high context* and *low context*:

> "A high-context (HC) communication or message is one in which most of the information is either in the physical context or internalized in the person, while very little is in the coded, explicit, transmitted part of the message. A low-context (LC) communication is just the opposite; i.e., the mass of the information is vested in the explicit code." (Hall, 1976, p. 91)

For Hall, interaction with a computer is similar to a low context communication, since "if the information is not explicitly stated, and the program followed religiously, the meaning is distorted (Hall, 1989, p. 229)."

[5] Rotter (1966), as cited by Trompenaars (1993, p. 141-142).

Speed of Messages This variable refers to the speed with which people decode and act on messages. Some cultures feel more comfortable with fast messages in many instances, other cultures prefer slow messages.

Among the examples of slow messages, we have: deep relationships, works of art, television documentaries, poetry and books. While fast messages include: headlines, cartoons, television commercial, manners and propaganda.

Space This variable studies how people use space as a function of culture. In other words, the effect of culture on the structuring and use of space. It deals with undeclared rules about laying out houses, land and towns Hall (1966). Hall proposes four categories: *Territoriality*, *Personal Space*, *Multisensory Space*, and *Unconscious Reactions to Spatial Differences*.

Personal Space. Cultures have their own perceptions on personal space and follow unspoken and unconscious rules to determine its boundaries and when it is violated. In Northern Europe, for example, people don't touch other, "and even brushing the overcoat sleeve of another in passing is enough to warrant an apology" (Hoft, 1996, p. 53).

Territoriality includes concepts about "ownership" and extends to how space communicates power. An example of this are the interior layouts in offices. In some cultures, power or status of people is visible in the space extension, while in others, there is not a clear difference. In the USA, people with power have large offices on the highest floors of buildings. However, it is difficult to know who has authority in Japan, using the same patterns.

Multisensory Space. Invisible spatial boundaries extend to all the five senses, defining unconscious rules about what is too loud and intrusive. This may be related to *contexting*. For example, in low-context cultures, like in Germany, loud conversations are perceived as infringing on others' private space. The contrary happens in high-context cultures, as in Italy, where loud conversations are expected.

Unconscious Reactions to Spatial Differences. This variable refers to the distance you keep when having a conversation, it may influence the response that the person gives to the other and their conversation. Greater distance than expected may produce an unconscious and negative message.

Time Hall classifies the concept of time in two categories: *Polychronic Time (P-Time)* and *Monochromic Time (M-Time)* Hall (1989, 1990). At first, Hall acknowledged this different temporal conception from his Spanish friend who does many things at once, without any linear schedule.

P-time and *M-time* state for two different kinds of solution to the use of both, time and space when organizing frames for activities. This variable studies temporal issues and interrelated elements such as communication, human relationships and activities development.

Polychronic time refers to the preference of doing many actions at the same time. It emphasizes involvement of people and completion of transactions rather than sticking to preset schedules. Human relationships are more valuable than tasks or jobs, as happens in Middle Eastern, Latin American and Mediterranean cultures.

At the other hand, *monochronic time* is characterized as "being sequential and linear." It stresses schedules, segmentation and promptness. Monochronic time people try to respect planned timetables as possible. This classification includes Northern European cultures.

Information Flow This is defined as the measure of "how long it takes for a message intended to produce an action to travel from one part of an organization to another and for that message to release the desired response" (Hall, 1990, p. 22).

According to Hall, high-context cultures give more value to information and relationships than schedules. Inside these cultures, information tends to flow freely and fast. While in low-context culture information flow tends to be slow, since everything tends to be compartmentalized and bureaucracies flourish.

Action Chains This variable is borrowed from the field of animal behavior. It describes the interaction process carried out when one event releases another in an uniform patterned way. Each Action chain has a starting point, a climax, and finishes with a number of intermediate stages. This varies from one culture to another. A short action chain, for example, such as a hand shake may have different steps and stages: who will extend the hand first, senior or junior, or no matter, how many times hands should be shaken, what is the amount of grip pressure, etc.

Theoretical Consideration 3.2. *From Hall's model, we think it is important to consider the use and structuring of space as a cultural function. Let us adapt its vision regarding space to formulate the question: is it possible to structure the interface spatial components according to the users' culture?*

3.4.2 David Victor

LESCANT is a model of cultural variables developed by David A. Victor (Victor, 1992). The name is the acronym for *Language*, *Environment and Technology*, *Social Organization*, *Contexting*, *Authority Conception*, *Nonverbal Behavior*, and *Temporal Conception*. With this model, David Victor intended to provide a framework for formulating the right questions in an international business environment, where cultural differences play an important role.

LESCANT is the result of combining already existing models, as Hofstede's, Hall's and Kluckhon and Strodbeck's. Therefore, many similitudes and common elements can be found between those models and Victor's work.

Language According to Victor, language is a significant influencing factor on culture, and "the most obvious difference that international business communicators are likely to face (Victor, 1992, p. 15)." Victor studies different language aspects, including: *linguistic determinism*, *language as a cultural password* and *linguistic equivalence*.

Linguistic determinism is the assertion that one's view of reality stems largely from the language one uses. The way people think and behave is unconsciously by linguistic forms. With *language as a cultural password*, Victor refers to the fact that language itself can help outsiders to participate in a culture and gain the trust of its members. And third, *linguistic equivalence*: in the best of the cases, translations from one language to another provide equivalence, not the exact reproduction of a certain culture's meanings. Misunderstandings in another culture may be caused by words that seem to be well-translated.

Environment and Technology This variable describes the nature of the environment where people live and work. As Victor states, to survive, people adapt to the natural world that surrounds them, and doing so, they define an essential and integral part of their own culture. The natural world is the building block on which the superstructure of adaptive behavior is erected.

Five physical elements seems to have the strongest influence on culture, according to Victor's point of view: (1) climate, (2) topography, (3) population size, (4) population density and space usage and (5) relative availability of natural resources. Societies have to deal with these factors in their own way. These factors present different effects on a culture, depending on the physical setting of that people.

Climate: Victor suggests that most of a nation's development is influenced by environmental factors such as climate. Victor cites Andrew Kamarck (1976), who links tropical climate to underdevelopment, arguing increased levels of harmful insects, parasites and disease. Even if Kamarck notes that it is dangerous to attribute all development level to environmental causes, Victor affirms that factors such as climate do impact over a nation's development and cultural mind-set. "That is because any environment universally affects the behavior of those who live there (Victor, 1992, p. 49)."

Topography: Victor defines *topography* as "an area's physical and natural features, such as mountains, bodies of water, and internal distances (Victor, 1992, p. 52)." There are some cases where topographical conditions can produce strong cultural differences inside the same country, which, in Victor's vision, a person conducting business should be aware of. In Switzerland, for example, mountains have made each of the Swiss cantons a distinct cultural entity, with four major cultural regions divided according to linguistic lines.

Another example of the influence of this element is provoked by the relative small size and excellent natural harbors in the Netherlands. These conditions have made Dutch people look beyond their borders and moved toward internationalism. Already from the time of the establishment as a nation in the 17th century, Dutch businesses have relied heavily on navigation.

Population size: This is a major factor in the sense of how members of a society view the world that surrounds them. Industrialized nations with small populations are often export-driven, like Sweden or Switzerland. Their business depend strongly on international markets. On the other hand, companies in countries with larger populations can rely on their domestic market, at least, as an initial option before looking for transnational business.

Population density and space usage: Underlying assumptions about how people use their environment depend strongly on population density, including use of land, transportation, and even the way to park. In turn, such assumptions affect business behavior and communication. In crowded cities, transportation may not be efficient, "traffic jams make it harder for people to arrive at appointments on time." Business people in densely populated Hong Kong have become more flexible about being punctual, than either England or China.

Availability of natural resources: Available natural resources, existing ecological factors and interrelationship of people to their environment influence a country's development and remain in its history, and from there, in its culture in general. At an elementary level, everyday aspects like taste of food are influenced by the relative availability of one item over another. In business, environment also plays an important role in defining attitudes toward conservation of natural resources.

Social Organization This broad variable is defined by Victor as the common institutions and collective activities shared by members of a culture. Educational, economic, social, political and religious systems affect business communication. Victor lists ten areas where social values seems to have more interest in the business environment, because of their influence on the workplace: (1) kinship and family structure, (2) educational systems and ties, (3) class systems and economic stratification, (4) gender roles, (5) individualism versus collectivism, (6) religion, (7) occupational institutions, (8) political and judicial system, (9) mobility and geographic attachment and finally, (10) recreational institutions.

Contexting Victor expands Hall's model of Contexting to include the work of Rösch and Segler (1987, p. 60), who ranked cultures using Hall's context square. In Victor's terms, Contexting is "the way in which one communicates and especially the circumstances surrounding that communication." Like Hall, Victor proposes two categories for contexting: *high* and *low*.

When individuals have considerable common knowledge and experience, their communication is generally highly contexted. What they choose *not* to put into words is essential to understanding the actual message intended. When communicators rely relatively little on shared knowledge and experience, communication is low context, and more information must be explicitly stated.

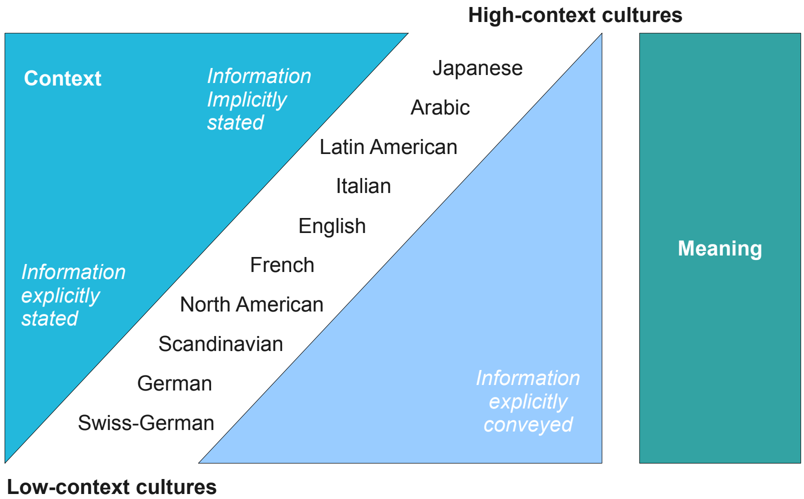


Figure 3.2: Nancy Hoft's interpretation of Hall's Context Square and Victor's diagram of the Context Ranking of Culture (Hoft, 1996)

Authority Conception: Power Perception and Leadership Style This variable considers differences and similarities in power, authority, and leadership. Cultures may perceive them in very different ways, and this perception affects business communication. We are not going into further details regarding this dimension since it has been already described in Hofstede's model (See Section 3.3.2).

According to Victor, authority goes beyond power, to include notions of leadership style. This can be seen as the aspect of authority that places the application of power in its symbolic context. A symbolic context of actions through which people in power cause others to do what they wish them to do. "Power represents substantive action; leadership style is determined by symbolic action." Cultures present different understandings of power, particularly in the following three points: the perception of power, power distance and the function of the leader.

Theoretical Consideration 3.3. *The authority institutions might be important in the classroom. How school work is organized according the authoirity roles in the classroom? How computer tools should be designed according to this organization?*

Nonverbal communication David Victor includes in this category different forms of nonverbal communication having an impact over international business. To specify what this dimension is, Victor chooses the definition given by nonverbal communication expert Randall Harrison, cited by Victor, as "the exchange of information through non-linguistic signs (Victor, 1992, p. 185)."

Victor classifies nonverbal communication in two types: *active* and *passive*. Active nonverbal communication can be consciously modulated. On the other hand, people have less control over passive nonverbal communication. Victor includes six categories of active nonverbal communication: (1) movement, (2) appearance, (3) eye behavior, (4) touching behavior, (5) space usage and (6) sounds. And four categories of passive nonverbal communication: (1) colors, (2) numerals and counting indicators, (3) symbols and (4) smells.

Theoretical Consideration 3.4. *Given than the interface is composed of different kinds of signs, beyond written code: gestures, colors, sounds, symbols, etc., we think it is important to consider the possible cultural meaning of these signs in the interaction with computers.*

Time Conception Victor studies various perspectives about time concept, focusing on Hall's Polychronic time (P-time) and Monochronic time (M-time) and how they impact business communication, specially about scheduling.

3.5 Summary

In this chapter we have given a short summary regarding culture-related works, focusing on five well-known and tested existing models, those of Kluckhohn and Strodtbeck, Hofstede, Trompenaars, Hall and Victor. As we have explained, the model components depend on the goals, needs and context. The models presented here have mainly a business-focus, and they are not fully suitable to study a culture to develop computer tools. Nevertheless, we can take them as base and adapt their variables according to our needs.

The application of these models will be described in Chapter 7, where we will elaborate a model aimed at the study of pedagogical computer tool user's sociocultural context.

Human nature	Univ. vs. Particularism	Masculinity vs.
Man nature	Neutral or emotional	Uncertain avoid
[illegible]	[illegible]	[illegible]

Figure 3.3: Summary of variables studied by the cultural models presented here.

Chapter 4

Semiotics and Human-Computer Interaction

The aim of this chapter is to introduce basic foundations to understand Human-computer interaction (HCI) as a culture-dependent process. Let us consider a twofold statement: (1) interaction with a computer has similarities with a communication process (2) that takes places through a computer interface composed of signs. If this statement is accurate, semiotics, being the study of signs, meaning, and their role in communication is part of the fundamental theories needed to understand how the sociocultural contexts of developer and user influence HCI. As we state in this chapter, the interpretation of signs largely depends on the interpreter's sociocultural background.

Compared to other study fields, such as philosophy, linguistics or design, the application of semiotics in HCI or computer science is more limited. Researchers such as Andersen (1997, 2001), Nake and Grabowski (2001) and de Souza (2005), de Souza et al. (2006) have done notable contributions. Nake and Grabowski (2001) affirm that the study of signs is fundamental to understand human-computer interactions. However, other researchers, such as Andersen (2001) doubt about the practical insights that it can offer to HCI, although he earlier proposed a theory of computer semiotics (Andersen, 1997). Nevertheless, we can find an exhaustive work done by Clarisse S. de Souza, who has developed a Semiotic Engineering theory (de Souza, 2005), and formulates some methods for evaluating interfaces design (de Souza et al., 2006).

their signification relationships.

As the statement identified at the beginning of this introduction, we divide this chapter in two parts, the first corresponding to HCI as a communicative exchange, and the second one related to signification and meaning.

4.1 HCI as a communicative exchange

With the metaphor that HCI IS A COMMUNICATION PROCESS[1], we are referring to a message exchange process between the user and the developer of the system, not to a user-to-user computer-mediated communication. In this developer-user exchange, messages are transmitted via the interface using different forms of signs: words, graphic icons (such as the *paste* icon shown in Figure **??**), sounds, gestures, etc.

To affirm that interaction between human beings and computers presents characteristics of communication processes is not new. This has already been stated by researchers such as Nake and Grabowski (2001) or de Souza (2005). According to Nake and Grabowski's point of view, HCI is a pseudo-communication process. They use the prefix "pseudo-" because, according to them, HCI lacks some decisive communicative features: "because the human's actions in pursuing his or her interest, and the computer's operations in following its routines are so fundamentally different that it appears silly to think of any kind of similarity of the two subsystems in that pseudo- communicative situation" (Nake and Grabowski, 2001, p. 445). On the other hand, C. de Souza characterises HCI as a computer-mediated metacommunication (de Souza, 2005). She affirms that during interaction there is a dialog between the user and a developer's deputy. This deputy represents the developer through the system interface.

Without aiming to challenge these ideas, we can give more precision to the metaphor stated above: HCI IS A COMMUNICATION PROCESS BETWEEN SYSTEM DEVELOPER AND USER. As stated by Lakoff and Johnson (2003), metaphors are not the actual entity they replace and cannot have the same characteristics. In this case, HCI is not an actual user-developer communication process, although this analogy allow us to understand some issues and establish our research goals.

Before going further, we can consider two communication models to gain understanding in this kind of process: (1) the Jakobson (1960)'s model (see Figure 4.1), which is taken into account by Clarisse de Souza (2005) to develop

[1] Small capitals are for using the Lakoff and Johnson's notation to define metaphors (Lakoff and Johnson, 2003)

her Semiotic Engineering approach, (2) the elementary communication model proposed by Umberto Eco (1976).

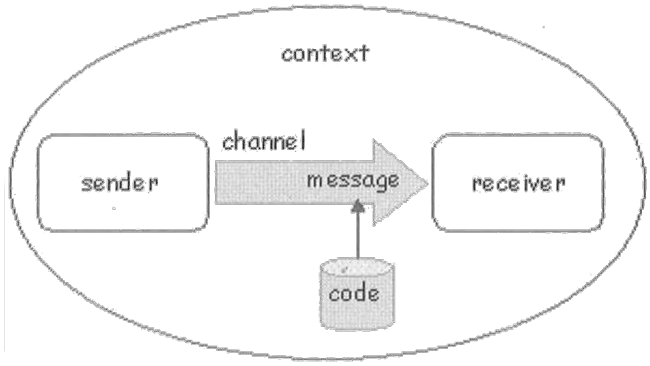


Figure 4.1: Jakobson's model of the communication space, according to de Souza (2005, p. 66)

On the one hand, de Souza (2005, p. 96) affirms with respect to a communicative process: "a sender issues a message in order to achieve certain kinds of effects. The receiver is the one who gets the sender's message. The message is transmitted through a channel and must be encoded in a signification system that is shared by sender and receiver–the code. The message always refers to a context, which is the sum of all elements that affect the semiosis[2] of sender and receiver involved in the same communication process. . . "

On the other hand, Eco (1976, p. 32) considers additional elements in his model, represented in Figure 4.2. Eco differentiates the *source* of information from the *transmitter*, the information transmitted through the form of *signals*, and a *receiver* that, according to a *code*, converts the *signal* into a *message* finally delivered to a *destination*.

Eco states that "every communication process must be explained as relating to a system of significations" and, at the same time, "every pattern of signification is a cultural convention." However, the communication model presented by Eco allows him to differentiate a communicative process in which there is no cultural convention at all (the passage of stimuli). According to Eco, this process occurs, for example, when two mechanical devices transmit physical "information."

Eco exposes the communication process through the "Watergate Model" example, based on Mauro (1971). In the Watergate Model, an engineer creates a system to be informed downstream about the level of water in a basin. In turn,

[2]We will explain the semiosis concept in the following section

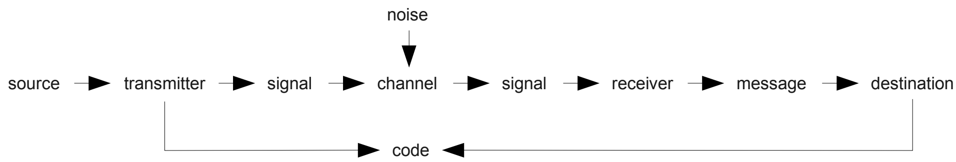


Figure 4.2: Elementary communicational model, based on the (Eco, 1976, p. 32)

we can adapt this example to the computer systems domain. To simplify, we take into account the Jakobson's model, proposed by de Souza, since it seems to be sufficient in our research context.

We can consider that an ICT expert who produces a computer tool that regularly verifies the status of software components installed on the computer and checks for new versions available on Internet. Whether there are new versions to be installed or if the system is up-to-date, whether upgrading is urgent to correct important security flaws or there are minor changes to be applied, all this composes pieces of information. All this information can be transmitted by the update manager, that we can consider as a *source* of information. The developer creates in the update manager a sort of method that, when detecting new versions, activates a *transmitter* (or *sender*). This transmitter is capable of submitting a *message* in the form of graphic and auditive *signals* from *channels* that compose the computer interface. The computer user (*receiver*) perceives these *signals*, and thanks to a previously learned *code*, will unfold the *message*. Hence, the interface deputy of the developer and the user must share the communication *code* so the *meaning* of the message can be successfully unfold. This meaning process it the object of the next section.

Before concluding this part of the chapter, we think it is important to briefly show other characteristics of communication. de Souza (2005, p. 66) identifies six (non-mutually exclusive) functions of language in the Jakobson communication model, each corresponding to one element of his model. These functions are the *expressive* function, the *conative* function, the *referential* function, the *phatic* function, the *metalinguistic*, and the *poetic* function. De Souza offers what, according to her, are examples of each of these functions in computer interfaces. To limit the scope of this thesis, we are not going into further details regarding theses functions or other communicative aspects, but we believe that communication theories can bring important insights to the study of HCI. At this part of the work, we will consider signification concepts, related to the communication process.

Theoretical Consideration 4.1. *Interaction with a computer can be seen as a communication process between the user and a developer's deputy. This is important in the context of this thesis because, as stated by Eco, a communication process refers to a system of signification, which, in turn, is based on cultural conventions.*

A communication element relevant to our research questioning is the code, which should be shared by sender and receiver in order to make the communication successful.

4.2 Signification and meaning

From the HCI point of view, de Souza (2005, p. 26) defines signification as "the process through which certain systems of signs are established by virtue of social and cultural conventions adopted by the (computer) users, who are the interpreters and producers of such signs." This statement introduces the concept of sign, the basic element of semiotics. To define what a sign is, let us briefly consider two main streams studying the signification process: the first one attributed to Ferdinand de Saussure and the second one elaborated by Charles S. Peirce.

In the work attributed to de Saussure (1916), *semiology* is conceived as the science of the study of signs, with an especial focus on language. As summarized by Eco, de Saussure defined a sign as a twofold entity, composed of signifier and signified, or sign-vehicle and meaning (Eco, 1976, p. 14). On the other hand, Peirce (1931-1958) developed what he called semiotics, that is "the doctrine of the essential nature and fundamental varieties of possible semiosis" (5.488). Peirce defined *sign* or ***representamen***, as "*something which stands to somebody for something in some respect of capacity. It addresses somebody, that is, creates in the mind of that person an equivalent sign, or perhaps a more developed sign. That sign which it creates I call the* ***iterpretant*** *of the first sign. The sign stands for something, its* ***object****. It stands for that object, not in all respects, but in reference to a soft of idea...*" (2.228).

Conversely to de Saussure's twofold sign, Peirce affirmed "All dynamic action, or action of brute force, physical or psychical, either takes place between two subjects... By semiosis I mean, on the contrary, an action, an influence, which is, or involves, a cooperation of three subjects, such as a sign, its object and its interpretant, this tri-relative influence not being in anyway resolvable into actions between pairs" (5.484). Thus, according to de Saussure's definition, the words /car/[3] and /voiture/ (signifiers) refer both to «automobile» (signified).

[3] As a manner of consistency with Eco' works, when referring to signs, single slashes denote

But the Peirce's sign concept makes explicit the role of English- and French-speaking competent readers, respectively, as interpreters of these signs.

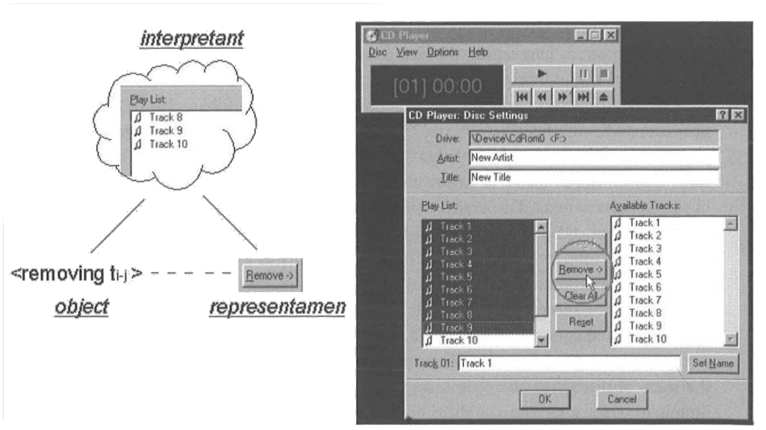


Figure 4.3: An interface element explained as a sign, according to de Souza (2005, p. 76)

This three-entity sign is commonly *represented* through triangular structures, as the interface sign described by de Souza, shown in Figure 4.3.

Let us get back to the /clipboard/-paste sign example to represent it graphically in Figure 4.4. Instead of the triangular structure, we have selected the "inversed Y" structure, which, according to Perry (n.d.), draws more accurately what Peirce aimed to mean with respect to signs.

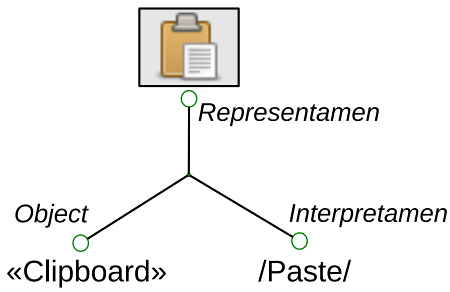


Figure 4.4: A triadic representation of the paste icon.

In a similar manner, other computer system elements, such as *classes*, can be outlined through their triadic meaning relations. For example, Figure 4.5 depicts the *class* ***Tree***, which is a *representamen* related to its *object*, a "real-

a interpretamen-representamen, whereas guillemets (angle quotes) refer to its object.

world" «tree», elaborated by an ICT expert, for whom this class would be an abstraction of /all types of trees/.

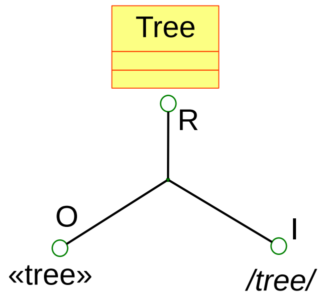


Figure 4.5: A triad sign representing the system class *Tree*.

Taking the sign definition back again, de Souza (2005, p. 39) states "nothing is a sign unless (or until) it is interpreted by somebody." "... It follows from this definition that the signs may have very different valid meanings, that mutual intelligibility widely depends on cultural conventions and mechanisms to negotiate shared meanings, and that ultimately there is no such thing as *the meaning* of a sing." In other words, there is not a universal *meaning* of a sign.

Theoretical Consideration 4.2. *If there is no such thing as a universal meaning of a sign, in the context of this thesis, we must consider the consequences of the interface sign exchange between individuals from different cultures.*

How do the users of a different sociocultural context than ours would interpret the interface signs that we will elaborate?

Of course, this issue is not exclusive of the HCI domain. As exposed by del Galdo (1996), in the 70's, a U.S.A.-based company sent to Iraq cereal grains, aimed to be used as seeds and treated with alkylmercury fungicide. To prevent its human-consumption, the cereal was dyed read and each sack of grain was marked with an English /warning/ and a /skull-and-crossbones/ symbol. Iraqi farmers did not read English and the skull symbol was meaningless for them. They washed off the red dye and they assumed any toxicity so did. But the alkylmercury stayed in the grains and these were milled into flour and transformed into bread. Thousands of Iraqis get poisoned by the fungicide and some hundreds died among them. This is an extreme and unfortunate case, but it clearly shows the impact of cultural differences on elaboration and interpretation of signs. The same signs that represented a clear message of danger in the U.S.A. context, signified nothing for the Iraqi farmers.

This example also illustrates why, as stated by Eco (1976, p. 66), meaning is a cultural unit: "Every attempt to establish what the referent of a sign is forces us to define the referent in terms of an abstract entity which moreover is only a cultural convention." Now that we have defined the basic structure of sign and meaning, we can develop more insights about the concept of semiosis.

Theoretical Consideration 4.3. *The interpretation of signs, including those composing the interface, largely depends on the users' socio-cultural background.*

Semiosis: Beyond the single triadic sign, Peirce's main object of study was the semiosis. The concept of semiosis can be found in another basic definition of sign: *"anything which determines something else (its interpretant) to refer to an object to which itself refers (its object) in the same way, the interpretant becoming in turn a sign, and so on ad infinitum*" (2.303). Actually, when Peirce referred to a sign, he was not specifying a single triadic relationship, but an unlimited sequence of meanings, where the *interpretamen* of a sign becomes the *representamen* of a next sign, whose *interpretamen* becomes, in turn, the *representamen* of a yet new sign.

These limitless consequential relationships make that, rather than a simple triadic relationship, a sign would be a fully-developed meaning process: *"The meaning of a representation can be nothing but a representation. In fact, it is nothing but the representation itself conceived as stripped of irrelevant clothing. But this clothing never can be completely stripped off. . . "* (1.339). This idea was further developed by Umberto Eco, under the name of *unlimited semiosis* (Eco, 1976, p. 68). Eco affirms that "paradoxical as it may be, (the semiosis' unlimited character) is the only guarantee for the foundation of a semiotic system capable of checking itself entirely by its own means," as human language does. In other words, "the very definition of 'sign' implies a process of *unlimited semiosis*" (p. 69), which infer in a self-definition structure.

From this causal sequence of meanings, we can represent the relation of the /clipboard/ graphic icon with other system components, for example, a word-processor's paste function. Figure 4.6 shows a double triad, as the partial meaning process produced by the classes representing the paste function of a text editor. The /PasteButton/ class represents the «WordProcessor» class, which are associated through the methods /callPaste/ and «paste», respectively. As said before, /PasteButton/ refers to the clipboard icon and means the /paste/ action. Compared to single triadic signs, such as that of Figure 4.4, this unlimited meaning relationship has the advantage to explicitly show the relations among different system components.

As described before, another consequence of the unlimited semiosis is that

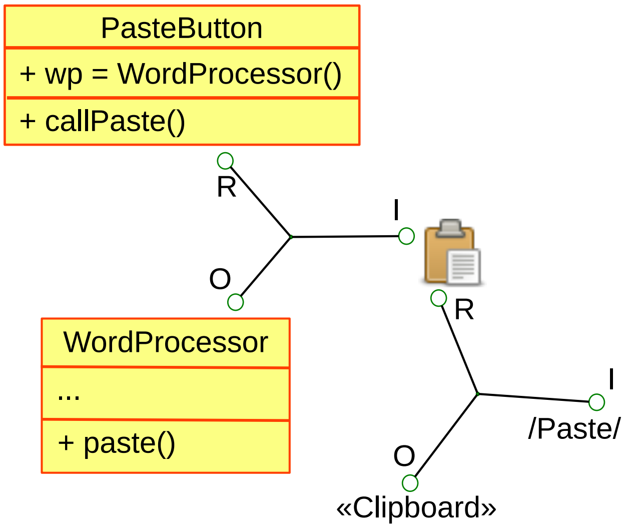


Figure 4.6: Double triad of the paste icon sign as a function of a text editor.

it implies a self-description structure, with possible circular references. To explain this, we can consider a simple example, also provided by Eco: /NaCl/ refers to «Salt», as well as /Salt/ refers to «NaCl» (p. 72).

Theoretical Consideration 4.4. *Question: Can this limitless meaning structure be useful to describe the relation between computer tool components?*

Before being able to answer the question stated in Theoretical Consideration 4.4, the different forms to represent computer system design should be studied. This study is described in the following chapter.

4.3 Summary

In this chapter we gave a brief summary regarding basic semiotics-related concepts: sign and unlimited semiosis. We have shown how a sign, more than a single triadic signification unit, is an unlimited interrelated sequence of meanings.

As drawn in this chapter, the elaboration and the interpretation of signs are part of communicative situations, which present some similarities with HCI processes. As stated by de Souza (2005), system user and a deputy of the developer exchange messages through the computer interface, as represented through Figure 4.7.

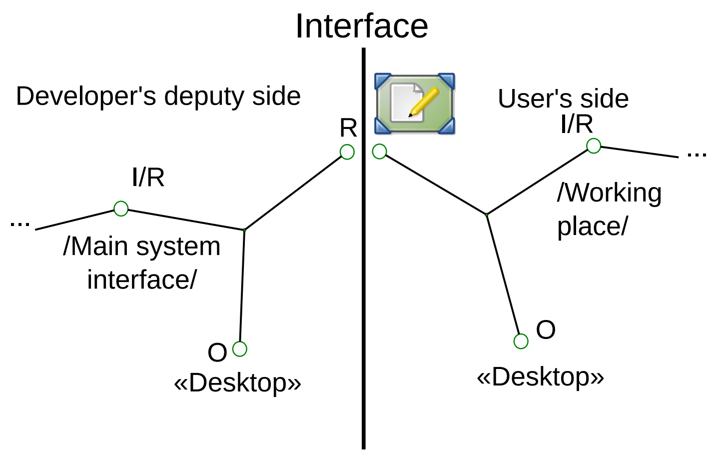


Figure 4.7: Two signs encounter in the interface. A desktop icon produced by the developer and interpreted by the user.

Given this sign elaboration-interpretation relation between the developer and the user, we can formulate the question: *is it possible to produce interface signs that lead the users to make the interpretation the developers want?* We think it is impossible to predict what the users' exact interpretations will be, but we can try to approximate meanings, studying the culture and selecting from it suitable elements in our design.

Similarly to any other communication medium, computer interfaces are composed of different forms of signs whose meanings largely depends on user's cultural background. Sender and receiver of the message should share the code in which the message is encoded to make it possible to successfully unfold the message's meaning. Therefore, as graphically represented in Figure 4.8, computer tool developers must elaborate interface elements according to the user's sociocultural background, using a users' familiar *code* in order to allow them to understand the encoded *messages*.

We think that the semiotic concepts presented here can be useful to describe the relations between computer system components in a determined sociocultural context, but we first need to study the forms to describe a system, which is the goal of the next chapter.

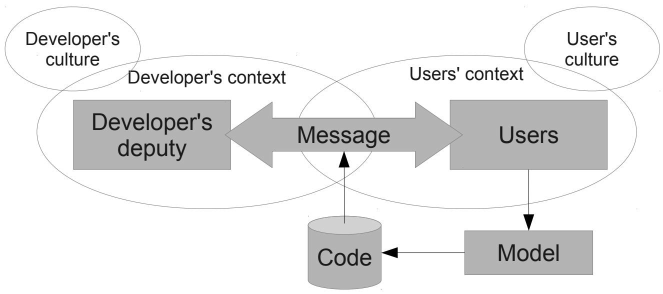


Figure 4.8: Modeling the users to elaborate a suitable communication *code* in human-computer interfaces.

Chapter 5

Modeling an Interactive System

In the previous part of the state of the art, we described theoretical tools that will provide support to understand the problem from a cultural perspective and to select relevant characteristics of the user's sociocultural context. In this second part, we give an overview of current interactive system modeling approaches to tackle the second research question: *how to describe the influence of the users' culture on interactive system design?*

The problem related to this question is to allow further developers to make use of our knowledge regarding the influence of users' culture on computer tool design. Therefore, we need to describe our designs in such a way that other developers can understand it. Moreover, we need to show the relations between the computer tool components and the users' sociocultural characteristics that motivate them. Hence, we can transform the research question from another point of view to clarify our problem: *How can further developers make use of our knowledge regarding the influence of users' sociocultural context on interactive system design?*

To answer this question, we can consider the models of information system engineering and their properties: (1) they provide a representation of the system entities in a formal language, reducing the ambiguity in the description. (2) They allow to conceptually abstract system entities, their properties, events and transformations. For Trætteberg (2002), the latter is especially important because it supports "mental synthesis and analysis within a domain." In our case, this domain is the relation between a particular sociocultural context and specific computer tool solutions.

For Trætteberg, the model graphical representation through diagrams that show the relation and arrangement between computer system parts is also important. These diagrams "enhances the understanding of the complex structures to solve complex problems" (Trætteberg, 2002, p. 2). Thus, interactive system design models seem to be a necessary approach to describe the system that we will need to relate to a specific sociocultural context.

Researchers such as Trætteberg (2002), Samaan (2006), Brossard et al. (2007) and Verdurand (2011), among others, have studied and compared different modeling perspectives related to human-computer interaction. Trætteberg (2002) aims to provide interface design by means of explicit representations (i.e. models). Samaan (2006) aims at providing models, methods and tools to construct interactive applications adaptable to different context of use, with respect to the computing platform. Brossard et al. (2007) propose a human-computer interaction modeling method based on business process, which aims to facilitate the communication between computing scientists and domain experts. Verdurand (2011) contributes to the modeling and predictive evaluation of multimodal interactive systems.

In this chapter we give an overview of different modeling perspectives: tasks modeling, architectural models and model-driven architectures. We will describe them in the following sections taking into account their chronological evolution.

5.1 Task-oriented models

As stated by Limbourg et al. (2001), a task is an activity that the user performs to accomplish a specific goal. Several task models have been developed to describe the tasks that the user can carry out by the use of an interactive system. Examples of those models include, among others: GOMS, User Action Notation (UAN), CTT, K-MAD and BPMN.

Despite all these models make it possible to describe the execution of tasks, they have different orientations and foci. For example, GOMS is strongly oriented to the user's performance, CTT considers cognitive issues and problem solving, and BPMN is focused on the domain business process. We give an overview of these models in this section.

5.1.1 Goals, Operators, Methods and Selection rules (GOMS)

GOMS is a family of goals-oriented models, including, among others: Keystroke-Level Model (KLM) (Card et al., 1980), NGOMSL (Kieras, 1994) and CPM-GOMS (John and Gray, 1995). GOMS organizes hierarchically the user's goals, decomposed in subgoals and selection routines. As previously said, GOMS is strongly oriented to the user's performance, focusing on the time to accomplish the task.

Description	Operation	Time (sec)
Reach for mouse	H[mouse]	0.40
Move pointer to "Replace" button	P[menu item]	1.10
Click on "Replace" command	K[mouse]	0.20
Home on keyboard	H[keyboard]	0.40
Specify word to be replaced	M4K[word]	2.15
Reach for mouse	H[mouse]	0.40
Point to correct field	P[field]	1.10
Click on field	K[mouse]	0.20
Home on keyboard	H[keyboard]	0.40
Type new word	M4K[word]	2.15
Reach for mouse	H[mouse]	0.40
Move pointer on Replace-all	P[replace-all]	1.10
Click on field	K[mouse]	0.20
Total		10.20

Figure 5.1: A task example on how to Replace a word, described in KLM notation. Taken from `http://www.cs.umd.edu/class/fall2002/cmsc838s/tichi/printer/goms.html`

According to Verdurand (2011, p. 60), this model has limitations such as: (1) it does not consider the possible feedback that the computing system may give to the user, (2) the task modeling is goal-oriented, without considering that they could be focused on solving cognitive problems, (3) it does not consider basic cognitive tasks, (4) the scarce operator possibilities make it difficult to consider different interaction possibilities, such as vocal or gestural, which are relevant in Verdurand's research context.

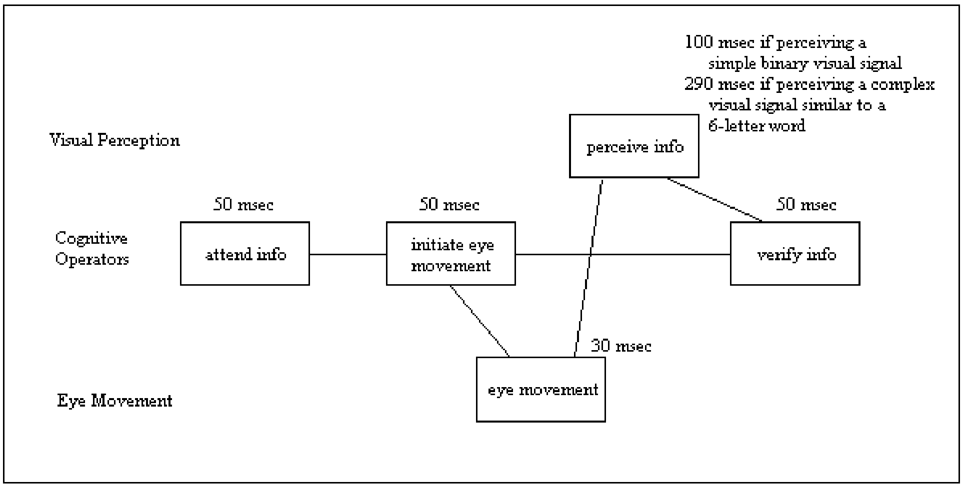


Figure 5.2: An example of CPM-GOMS Model

5.1.2 Concur Task Trees (CTT)

CTT (Paternò et al., 1997, Paternò, 1999) was developed to resolve issues found in previous notations. As we expose in the next section, it aims to support model-driven design through a high-level formal task model, focusing on the activities without considering the computer implementation.

CTT structures the task modeling in a hierarchical tree, in which the tasks can be atomic or subtasks that can decomposed until they reach an atomic state. The CTT's notation specifies the allocation, the type of tasks, the temporal relationships between the tasks, and the objects manipulated to perform those tasks.

Concur Task Trees specifies four types of tasks: *user tasks*, *application tasks*, *interaction tasks* and *abstract tasks*, which are described according to the notation shown in Figure 5.3. *User tasks* are performed by the user, they include cognitive activities, such as thinking about and deciding "what the best strategy to solve a problem is." *Application tasks* are completely executed by the machine. They can give information to the user, for example, presenting results after executing an operation. *Interaction tasks* are performed by the user with the machine by interaction techniques. *Abstract tasks* require complex activities whose execution "cannot be univocally allocated."

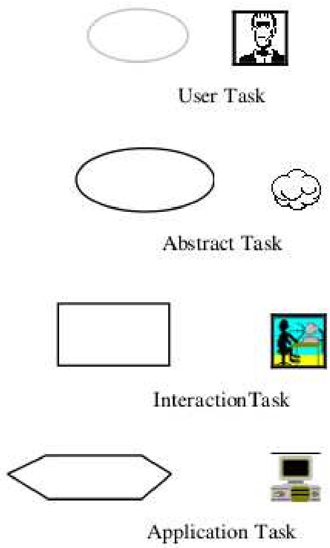


Figure 5.3: CTT notation. Image taken from Paternò et al. (1997)

5.1.3 Business Process Model and Notation (BPMN)

BPMN specifies a graphical notation for describing business processes. The BPMN's primary goal is to support business process management by the different stakeholders involved in the process: business users, business analysts, information technology experts, and business managers. Thus, BPMN aims to provide a notation easily understandable by business users, yet able to represent complex process semantics. Figure 5.4 shows an example of two business collaborating entities, described according to BPMN.

Theoretical Consideration 5.1. *If we compare the three task models described here, we can observe how the focus has evolved. Earliest task models were mainly interested in the execution of tasks in an implemented design solution. More recent models are rather problem-oriented, they consider higher abstraction levels, including cognitive-issues and business processes.*

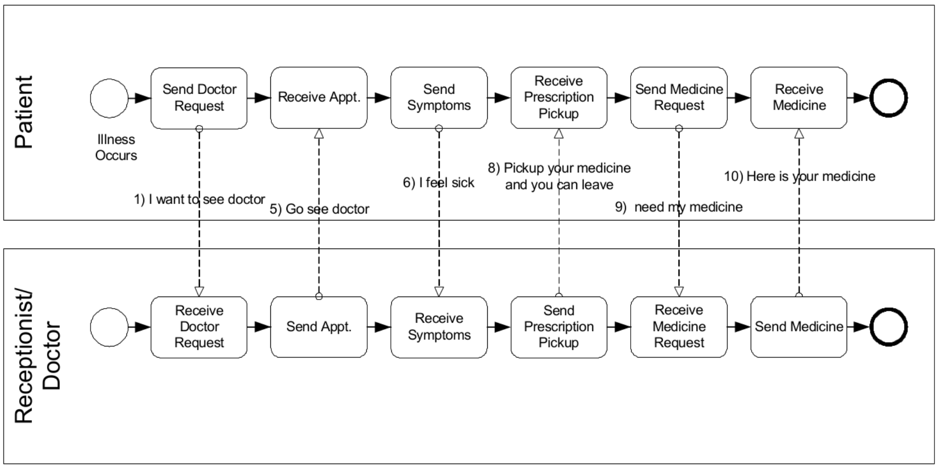


Figure 5.4: Example of a Collaboration Business Process. Taken from (BPMI, 2004, p. 24)

5.2 Architecture-oriented models

Unlike the models presented above, this section provides an overview of some models focused on the structure of the computer solution. Here, we consider four main architectural models that take into account the user interaction components: *Seeheim*, MVC, PAC and *Arch*.

5.2.1 Seeheim

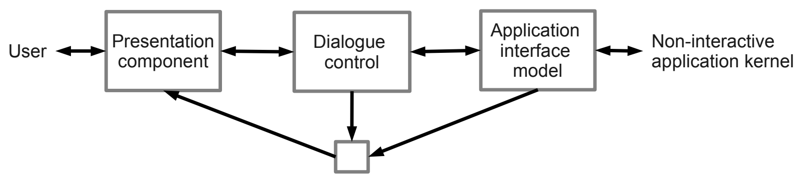


Figure 5.5: The Seeheim model

The earliest architectural interactive tool model that divided the user interface from the computing components was proposed during a workshop held in Seeheim (Pfaff, 1985). This model specified the user interface composed of three main logical elements: the *functional core*, the *dialogue control* and the *presentation*. The *functional core* contains the main domain specific functions. The *presentation* provides the user with the domain information and acquires the input given by the user. The *dialogue control* is in charge of the communication between the functional core and the presentation. This model is illustrated in Figure 5.5.

5.2.2 Model-View-Controller (MVC)

This multi-agent[1] model was introduced as the Smalltalk-80 user interface architectural reference model. MVC (Krasner and Pope, 1988) divides the system in three collaborating entities: *model*, *view* and *controller*. The *model* represents the business data and information to be manipulated, modified and visualized through the system. The *view* is in charge of providing the user with any output representation of the information given by the *model*. The *controller* is responsible for capturing and analyzing the input given by the users, and for controlling the events between the view and the model. Since MVC was initially developed for Smalltalk-80, it shares its object-orientation: *model*, *view* and *controller* are defined as three different *classes* composing the system. Figure 5.6 summarizes the MVC model.

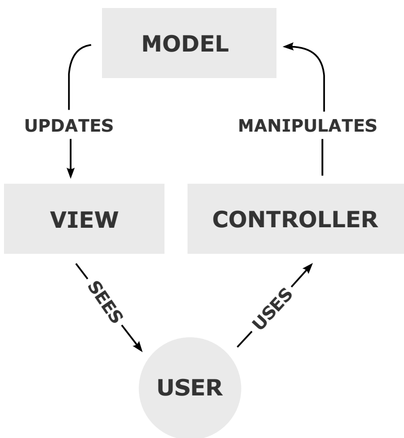


Figure 5.6: The Model-View-Controller architecture. Image taken from `https://commons.wikimedia.org/w/index.php?title=File:MVC-Process.svg` (Under Public domain)

[1]According to Ferber (1995), an agent is a computing independent entity, abstract or real, able to act over itself or over its environment.

5.2.3 PAC

PAC, for Presentation-Abstraction-Control (Coutaz, 1990), is another multi-agent architectural model. Despite the fact that there are also three basic entities that compose this model, we can identify two main differences with MVC. First, PAC specifies a hierarchical model of collaborating triadic agents, as shown in Figure 5.7. Second, their functions are not exactly the same than MVC's:

The *presentation* component is responsible for any information exchange with the user. It considers different forms: visual, auditive, tactile, etc., and it is equivalent to the *control* and *view* MVC components. The *abstraction* component is in charge of the semantic information processing. The *control* does not have a similar in MVC, it controls the dialogs between the agent and the user, as well as the dialogs with other PAC agents composing the system.

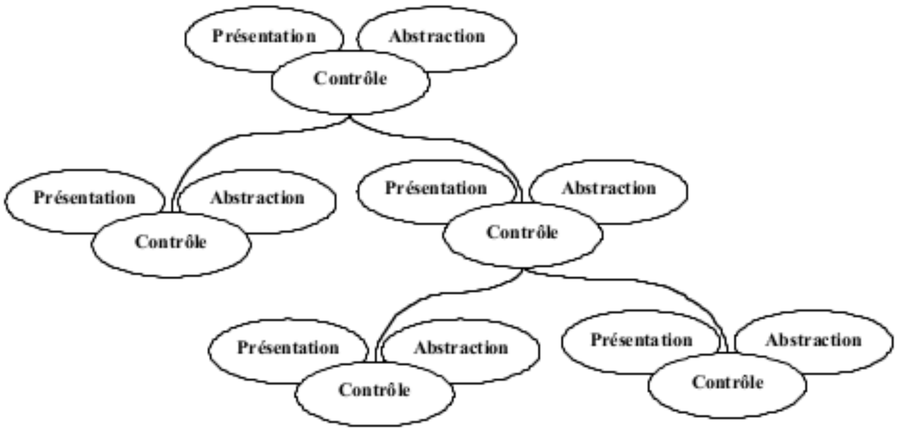


Figure 5.7: The Presentation-Abstraction-Control architecture. Image taken from Samaan (2006)

5.2.4 Arch

In 1992, the Arch model (UIMS, 1992), specified two additional components to the Seeheim model: *domain adaptor* and *interaction toolkit*. The *domain adaptor* mediates between the *dialogue control* and the *fonctional core*. It is responsible for the domain data organization to be interactively manipulated, and for detecting semantic errors.

Arch covers two different user interface abstraction levels through the *Presentation* and *Interaction toolking* components. The *Presentation component*

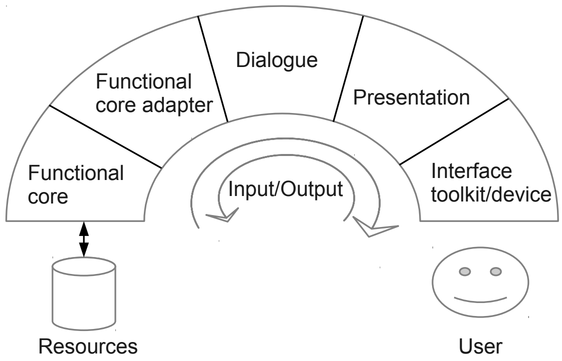


Figure 5.8: The Arch model

is a mediator, or “a buffer”, that administers a set of toolkit-independent objects, for example, a “Selector”, that can be interpreted by the *toolkit* as Radio-buttons or a Menu. The *Interaction toolkit* is in charge of concrete interaction objects and of the dialogue with the user. The Arch model is represented in Figure 5.8.

Theoretical Consideration 5.2. *Similarly to the task-oriented models, it is possible to observe the evolution in the degrees of abstraction of the architecture modeling. The three earliest models presented here considered three components. Arch, the last described model in this section, provides an additional degree of granularity between the user interface and the system computing core.*

5.3 Model-oriented architecture

A shift in the paradigm arose in the early 2000s, when the Object Management Group[2] introduced the Model-driven architecture (MDA) approach, which structures the design of computer systems by the means of models. MDA aims at supporting the Model-driven engieneering (MDE) development methodology, which places the domain model, instead of computer concepts, at the center of the development process.

MDA has three primary goals: portability, interoperability and reusability, “through architectural separation of concerns.” However, it is a large and ambitious approach that aims also, among others, to: “specify the system independently of the platform that supports it (OMG, 2003, p. 2-2);” make it easier

[2]The Object Management Group: `http://www.omg.org`

to develop computer tools through transformations from model to model in a descending approach; and provide the users with tools to create their own applications, independently of any operating system, hardware architecture, network compatibility or application incompatibility (OMG, 2003, p. 1-5).

As previously said, MDA proposes a descending development approach, which can be observed through three *viewpoints* described by means of models: Computational Independent Model (CIM), the Platform Independent Model (PIM) and the Platform Specific Model (PSM).

1. The CIM focuses on the system requirements and environment. It hides the system structure and processing mechanisms.
2. The PIM focuses on the operation of the system, while hiding the specific details for a determined platform.
3. The PSM gives more detail to the PIM, focusing on how the system uses a particular platform.

In the scope of human-computer interaction design, we can identify different approaches based on model-driven architecture. Among others: Trætteberg (2002)'s RML-based models, the CAMELEON Framework (Calvary et al., 2003), UsiXML (Limbourg and Vanderdonckt, 2004, Vanderdonckt, 2005), and Brossard (2008)'s Business process-based modeling.

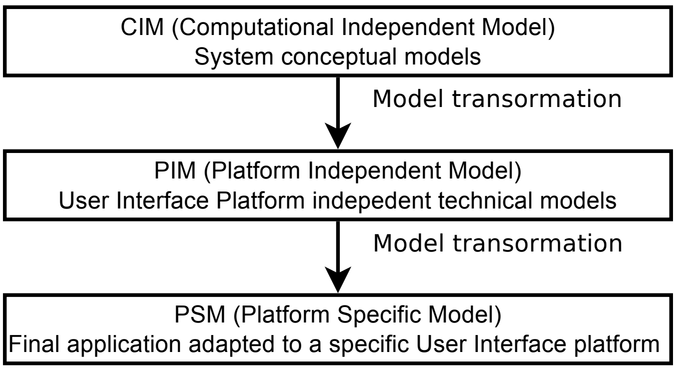


Figure 5.9: Model-driven user interface design, based on Brossard et al. (2007, p. 70)

These approaches cover, in different degrees, the different levels of model-driven user-interface design, shown in Figure 5.9. In the remaining part of this section, we provide a short description of these user-interface design-related approaches. For each approach, we show the models corresponding to the three MDA *viewpoints*.

5.3.1 Hallvard Trætteberg's RML-based models

In his Ph.D dissertation, Trætteberg (2002) introduced three modeling languages to describe the concepts, the tasks and the abstract and concrete interaction levels. These modeling languages are the Reference Model Language (RML) (Sølvberg and Brasethvik, 1997), the Task Modelling Language (TaskMODL) and the DiaMODL. RML serves to represent the concepts involved in the system, the tasks are described through TaskMODL and DiaMODL is used to describe both, the abstract dialogue and the concrete interactions. It is important to note that, despite the fact that model-based architecture and engineering concepts were in their earliest stages in 2002, Trætteberg's approach clearly differentiates the design levels according to the MDA *viewpoints*.

Computer-independent models: This viewpoint considers two types of models that constitute the domain: concepts and tasks. The *UML class diagram* is the most common approach to represent the concepts. However, Trætteberg (2002, p. 52) considers that these diagrams are "too informal, design-oriented and complex." Trætteberg proposes instead the use of the RML to model this design level.

According to Trætteberg, RML is based on language and set theory. Sølvberg and Brasethvik (1997, p. 10) took into account the "semiotic triangle" as theoretical foundation for the RML specification. Thereafter, the Reference Model Language is given its name by the language's feature to refer to real-world instances. RML makes is possible to identify real-world objects, describe their characteristics, relationships and governing rules. Figure 5.10 and 5.11 show the RML's notation and a modeling example.

Theoretical Consideration 5.3. *Despite RML is an interesting modeling language, its industrial and academic use seems to be very limited. The last version of the only supporting toolPPP Referent Model Editor:* `http://www.idi.ntnu.no/~ppp/referent/`*we found dates from 2000, and there is not evidence of further or active development. For the moment, we will consider UML Class diagrams to represent the domain design level.*

Concerning task modeling, in his Ph.D dissertation, Trætteberg develops the TaskMODL, based on the Action Port Model (APM) (Carlsen, 1998). Fig-

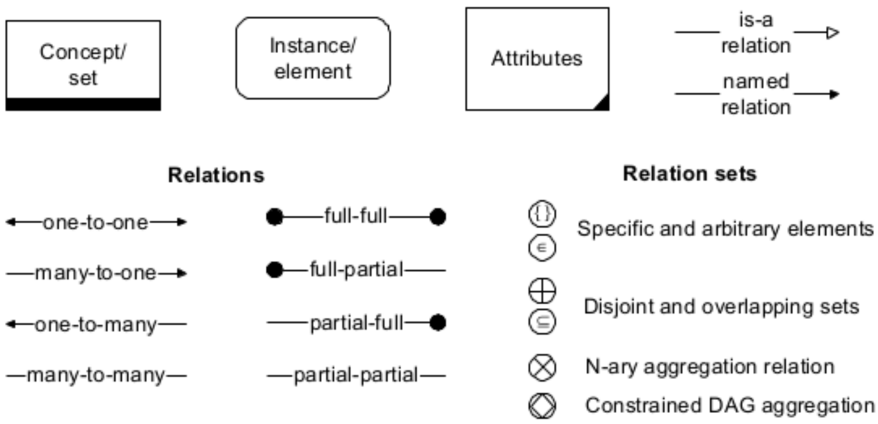


Figure 5.10: RML modeling notation. Taken from Trætteberg (2002, p. 52)

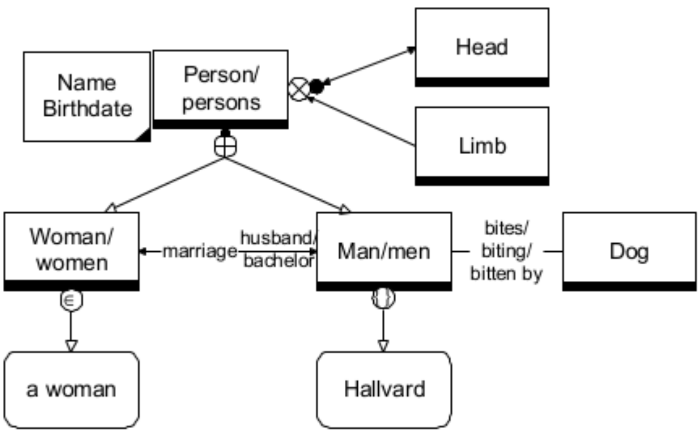


Figure 5.11: RML conceptual model example. Taken from Trætteberg (2002, p. 53)

ures 5.12, 5.13 and 5.14 show the basic TaskMODL notation and an example about the Read email task.

Nevertheless, with the goal of simplifying the available task modeling possibilities, (Trætteberg, 2008) proposes the use of BPMN for task description.

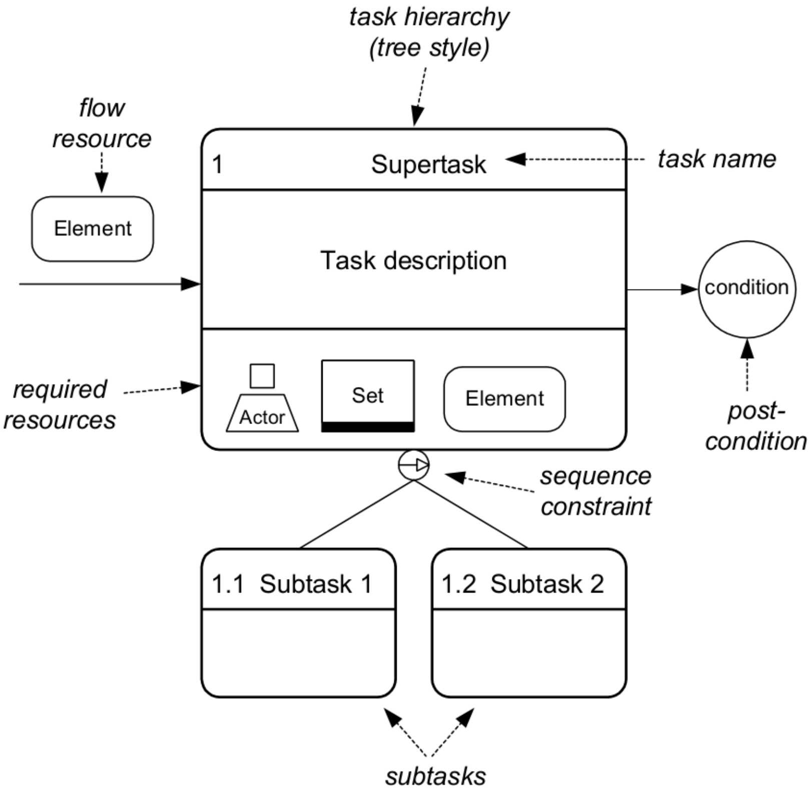


Figure 5.12: Basic TaskMODL constructs. Taken from Trætteberg (2002, p. 60)

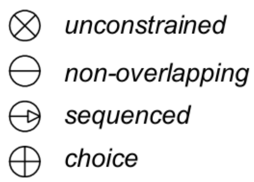


Figure 5.13: TaskMODL sequence constraints. Taken from Trætteberg (2002, p. 60)

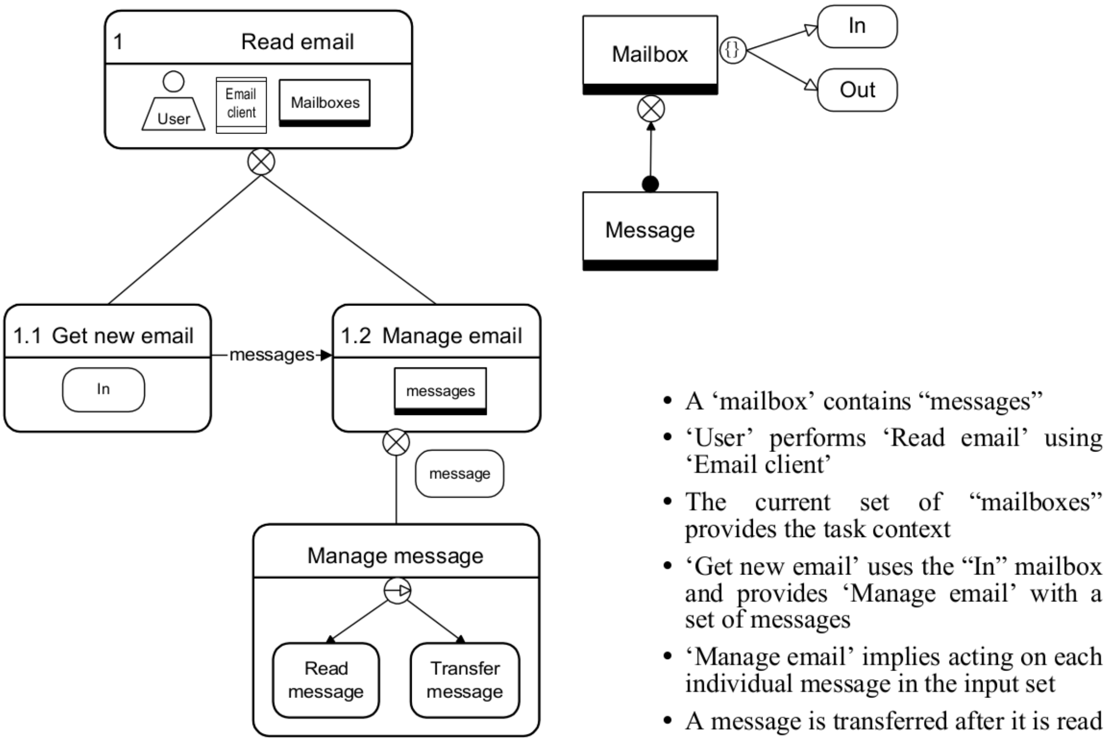


Figure 5.14: A basic TaskMODL example. Taken from Trætteberg (2002, p. 61)

Platform-independent models: In Trætteberg's point of view, the *dialogue modeling* (equivalent to the abstract interaction level) refers to high-level abstraction interaction that makes the user-system dialog possible. It describes the input/output information flow, activation and sequencing, independent of interfaces styles and end-user platforms.

To graphically represent this input/output information flow, Trætteberg developed the DiaMODL. Figures 5.15.

Platform-specific models: Platform-specific models: The concrete interaction focuses on the relationship between the dialogue and input/output devices (e.g. windows, widgets and pointing devices). Both levels are described by the Dialogue Modelling Language (DiaMODL), developed by Trætteberg.

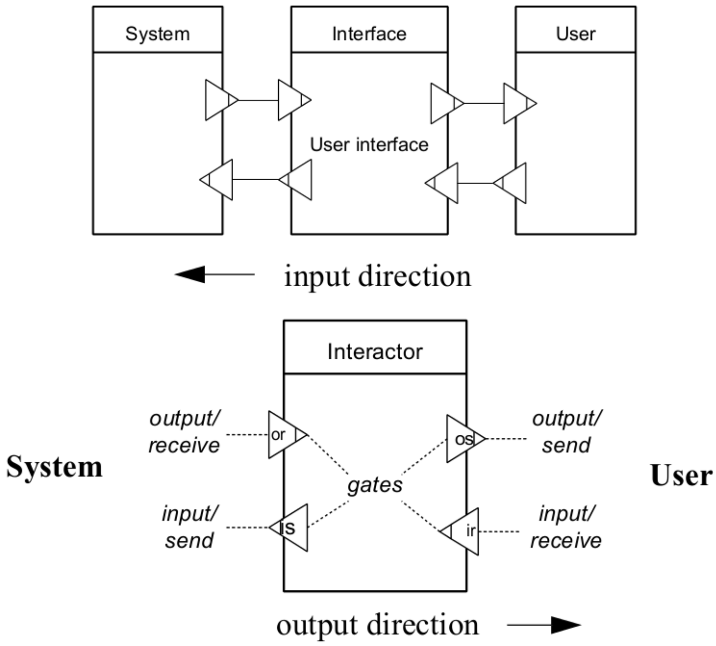


Figure 5.15: Mediation between computer system and user, represented through DiaMODL. Taken from Trætteberg (2002, p. 85)

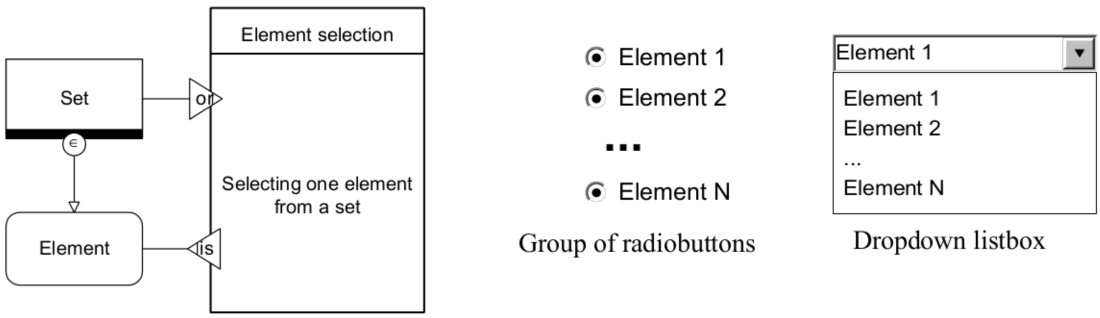


Figure 5.16: Example of element selection interactor described through DiaMODL and two corresponding concrete interactors. Taken from Trætteberg (2002, p. 93)

5.3.2 The Cameleon reference framework and the User Interface eXtensible Markup Language (UsiXML)

The Camelon framework (Calvary et al., 2003) (represented in Figure 5.18), and lately UsiXML taking Cameleon as base (Limbourg and Vanderdonckt, 2004, Vanderdonckt, 2005), formally propose a MDA-based development approach, considering different existing models. Similarly to OMG's MDA, the UsiXML's goals are also rich and ambitious. Likewise, UsiXML's specification and computer supporting tools are in development stage.

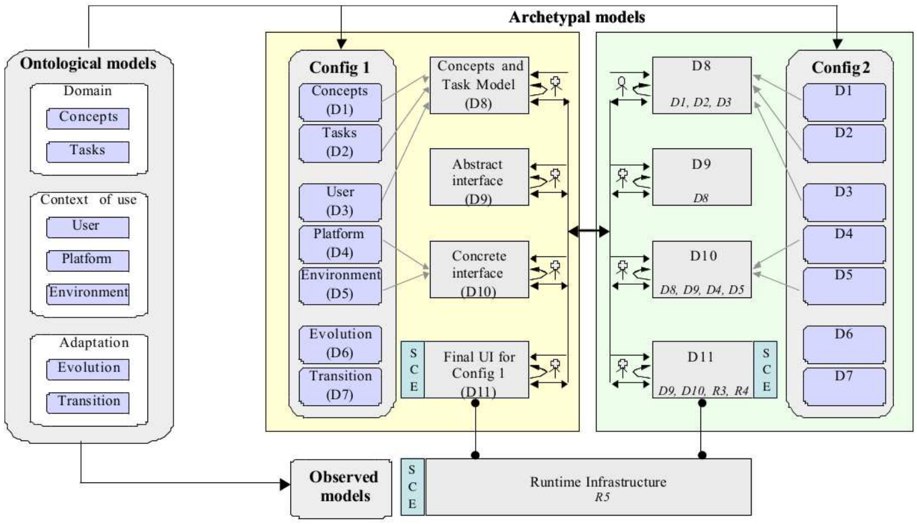


Figure 5.17: The unifying reference framework, as proposed by Calvary et al. (2003)

Unlike Trætteberg's approach, Cameleon and UsiXML consider a wide range of models oriented to the transformation among them, according to the supporting computing platform. In addition to the basic models –domain, tasks, abstract interface, concrete interface and final interface– covering the three main MDA *viewpoints*, UsiXML defines other models to support its goals. These models include, among others: *Transformation model*, *Mapping model* and *Context model*. Here, we limit our scope to the basic models for two reasons: (1) we are mainly interested in the description aspect of the interface design, which are covered by the basic models and (2) the UsiXML specification is still immature.

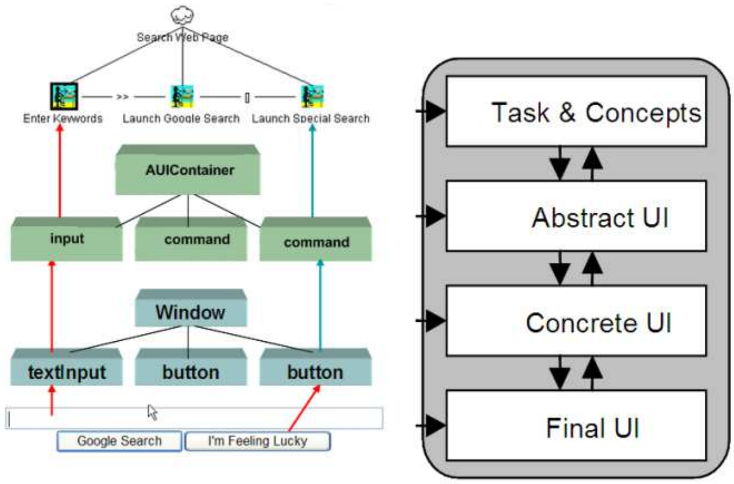


Figure 5.18: UsiXML reference framework. Image taken from `http://www.w3.org/2005/Incubator/model-based-ui/wiki/UsiXML`

Computer-independent models: UsiXML describes the highest abstraction level through two existing models: UML Class diagrams for the concepts and CTT for the tasks. This last shown in Section 5.1.2.

Platform-independent models: UsiXML defines the Abstract User Interface (AUI), composed of *Abstract Interaction Objects*, which can be containers and individual components, according to groups of subtasks defined in the immediate higher level.

Platform-specific models: the UsiXML's Concrete User Interface (CUI) concretizes an AUI for a specific context of use. The CUI is composed by *Concrete Interaction Objects* that determine widgets layout, navigation and general look & feel. However, a CUI is still a mock-up addressing a determined environment. The CUI is an intermediate abstraction between the AUI and the Final User Interface (FUI).

At PSM level we also find the FUI, which is the operational user interface able to run on a specific computing platform.

Theoretical Consideration 5.4. *UsiXML aims to be a complete MDA-based interaction design method. However, at the time of writing this thesis, a mature specification and computer supporting tools have not been released yet.*

5.3.3 PERCOMOM: A business-based approach

Brossard et al. (2007, 2011), Brossard (2008) have developed a business process-based modeling approach, called PERsonalization and COnceptual MOdeling Method (PERCOMOM). This is also an ambitious MDE-oriented modeling method, that embraces fourteen conceptual models to define the system. Here, we consider the three models directly concerned with the interface modeling: *Business Process Model*, the *Static Interaction Model* and the *Dynamic Interaction Model*. We also classify these models according to the MDA *viewpoints*, and show and example of their application at the end of this section.

Computer-independent models: According to Brossard (2008, p. 82), BPMN (briefly described in Section 5.1.3) is the most suitable language to (1) describe the system users' business goals, (2) give a reason to each user interface composing the system, (3) consider the different business tasks to accomplish a goal and (4) take into account the information exchange between the business users.

According to Brossard et al. (2007), an additional BPMN's advantage, compared to other similar models, is that BPMN is recommended by the Object Management Group (OMG), and it can be integrated into a MDA general approach.

Platform-independent models: the PERCOMOM's PIM level is covered by the *Static Interaction Model*. This model aims to: (1) model the interaction elements composing a computer tool; (2) group the interaction elements in similar sets, according to business processes; (3) define the relationships between interaction elements and (4) define the specific behavior for each interaction element. The *Static Interaction Model* defines a hierarchical structure of *interaction units* (*UIUnit*), whose simplified version is shown in Figure 5.19.

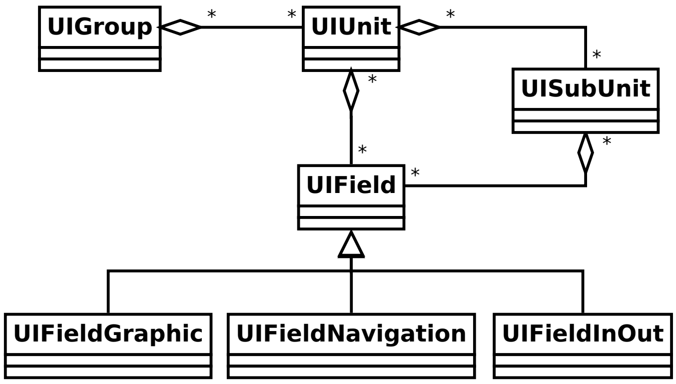


Figure 5.19: Simplified definition of Static Interface Elements, according to Brossard et al. (2007)

An example of a static interaction model is shown in Figure 5.21.

Platform-specific models: Brossard (2008, p. 82) limits the scope of his work to Windows Icons Menus Pointer (WIMP) interfaces, therefore, we do not find an intermediate model –equivalent to UsiXML's CUI– between the *Static Interaction Model* and the final implementation. However, PERCOMOM defines a *Dynamic Interaction Model*, which relates *interaction units* to the business processes in which they are involved. According to Brossard (2008, p. 93), the *Dynamic Interaction Model* is automatically produced by the supporting modeling tool. Figure 5.21 shows an example of three levels of a transportation information system modeling, according to PERCOMOM.

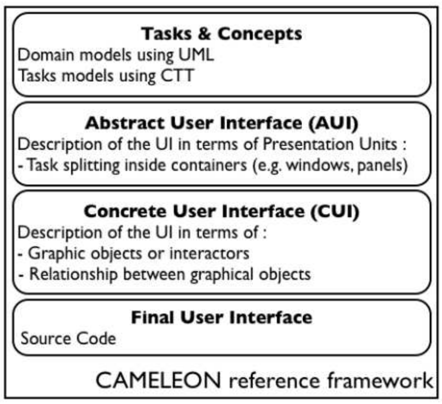


Figure 5.20: The CAMELEON Framework according to Brossard et al. (2011, p. 4)

It is important to note that, according to Figure 5.20, Brossard et al. (2011) considers windows and panels as abstract interactor containers. According to our understanding, the type of interface elements are defined at a concrete interaction level, since they represent a layout for a specific type of environment (WIMP in this case).

Theoretical Consideration 5.5. *PERCOMOM is a complete and exhaustive modeling approach that easily integrates the model-driven architecture approach. However, PERCOMOM presents an abstraction level less than UsiXML. I.e. the static interface elements in Figure 5.21 UIFielText and UIField-SimpleTable are html- or WIMP-oriented. While UsiXML's AUI or DiaMODL consider "generic" input/output interactors.*

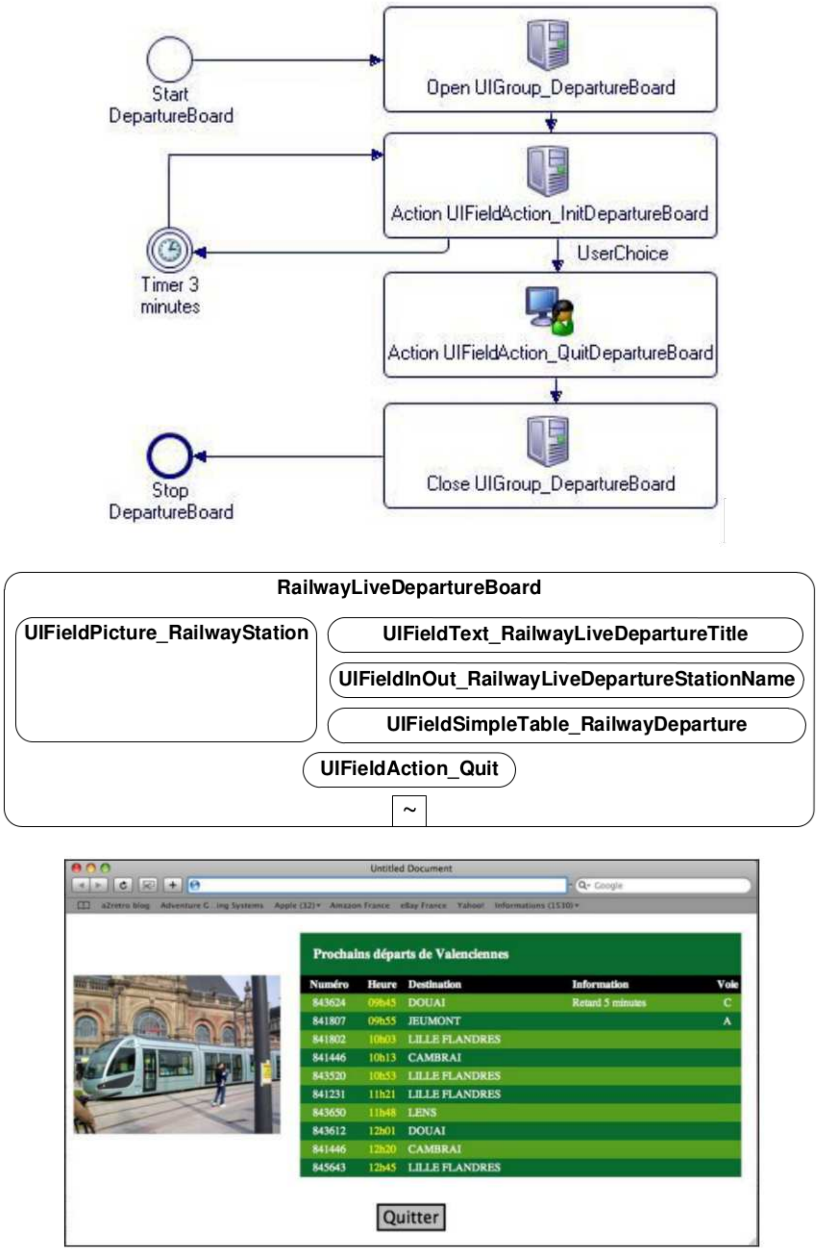
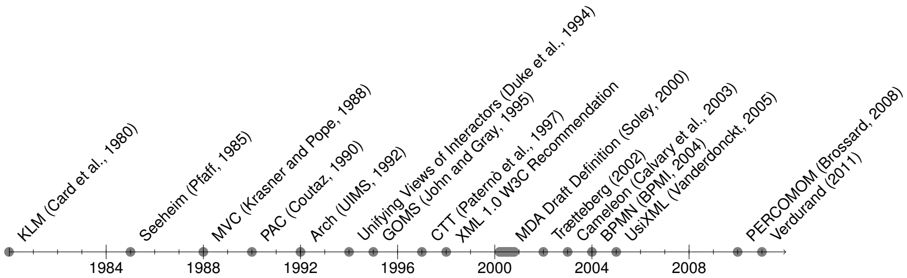


Figure 5.21: Examples of (top) a *business process model*, (middle) a *static interaction model* and (bottom) a generated web transportation system information interface. Taken from (Brossard et al., 2011, p. 14)

5.4 Summary

In this chapter we have briefly described different formal approaches to model an interactive computing system. We have classified these approaches in three categories, according to their perspective: *task-oriented models*, *architecture-oriented models* and *model-driven architecture*. The following timeline presents the years when the resources presented here arose. We can observe that the latest approaches converge towards a *model-driven development*, an ambitious and interesting paradigm, that places the domain, concepts, tasks, among other high-level models at the center of the development process.



In the case of user-interface development, we have mainly considered three MDA-based methods: the Trætteberg's models, UsiXML and PERCOMOM.

We will consider these methods to describe our Nasa people-specific design solutions, in order to tackle the research question: *how to describe the influence of the users' culture on interactive system design?*

Chapter 6

Design knowledge description methods

In the previous chapter we described different methods of interactive tool design modeling and we showed how the representation approaches have evolved into the current converging model-driven approaches. Even if these methods consider different abstraction levels of the system, their representation is limited to the final design and they do not give details concerning the design process. For example, they do not provide information regarding solution alternatives or the reasons to choose between them.

This chapter gives an overview of Design Patterns and Design Rationale, two design representation methods which provide additional information regarding the relationship between the design issue, the proposed solution and the design process. With this chapter, we aim at giving complementary insights to answer the question: *how to describe the influence of the users' culture on interactive system design?*

6.1 Design Patterns

In a general scope, Design Patterns are descriptions of reusable solutions to solve recurring problems. Alexander (1977) initially conceived patterns in the architectural design context, but his ideas have spread to other domains, including computer science and human-computer interaction.

In the computer science domain, and more exactly, in software engineering, design patterns gained popularity since Gamma, Helm, Johnson, and Vlissides (1995)[1] published their book *Design Patterns: Elements of Reusable Object-Oriented Software*. Through design patterns, Gamma et al. (1995, p. 15) aim to "record experience in designing object-oriented software." According to the definition given by *the Gang of Four*, an object-oriented design pattern:

> "systematically names, motivates, and explains a general design that address a recurring design problem in object-oriented systems. It describes the problem, the solution, when to apply the solution, and its consequences. It also gives implementations hints and examples. The solution is a general arrangement of objects and classes that solve the problem. The solution is customized and implemented to solve the problem in a particular context Gamma et al. (1995, p. 360)."

In a general context, a design pattern is composed of four essential elements: the *name*, the *problem*, the *solution* and its *consequences*.

1. The **Pattern name** is a brief description regarding the problem, its solution and its consequences.
2. The **Problem** describes "when to apply the pattern (Gamma et al., 1995, p. 3)"
3. The **Solution** describes the elements that compose the design, its relationships and collaborations. This is not the solution for a specific case, because a pattern is an abstract description that can be applied in different cases (related to a similar problem).
4. The **Consequences** are the outcomes, benefits and trade-offs that result from applying the described pattern.

In the case of object-oriented programming, Gamma et al. (1995) propose to describe design patterns following a uniform template, whose elements can be classified according to the four essential elements listed above:

The Pattern identification:

- **Pattern Name and Classification**: A short description of the pattern's essence.

[1] Gamma, Helm, Johnson and Vlissides are known as the Gang of Four.

- **Also Known As**: Other names for the pattern.

The Problem:

- **Intent**: A short description with regards to the reason behind the pattern, what is its rationale and what problem it aims to solve.
- **Motivation**: A detailed scenario that illustrates the problem and how the pattern solves the problem.
- **Applicability**: A list of situations in which the pattern can be applied. Examples of poor designs that the pattern can improve.

The Solution:

- **Structure**: A representation of the solution. Gamma et al. (1995) propose to use UML Class, Object and Interaction diagrams, according to their object-oriented programming perspective.
- **Participants**: A description about the elements that compose the solution.
- **Collaboration**: A description about the relationships between the pattern's classes and objects, and how they interact with each other.
- **Implementation**: A description of a specific implementation of the patterns' solution.
- **Sample Code**: A concrete example of how the solution can be implemented in a programming language.
- **Related Patterns**: Other patterns with some RELATIONSHIP WITH this one. A description about when they should be implemented together.

The consequences and additional information:

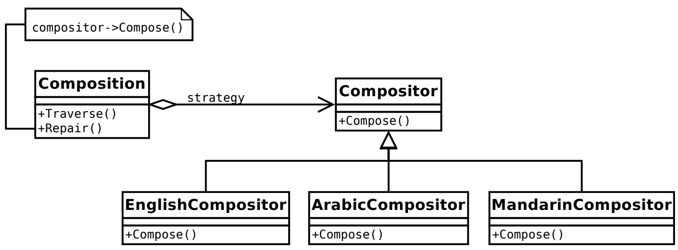
- **Consequences**: the outcome and trade-offs of using the pattern.
- **Known Uses**: Real examples of systems using this pattern.

According to Gamma et al. (1995), the use of this uniform structure makes it possible to compare the different patterns and identify their relationships. Gamma et al. (1995) also provides a catalogue of 23 classical design patterns, which can be classified in *Behavioral*, *Structural* and *Creational*. The following describes how we take a simplified version of the *Behavioral Strategy* Pattern, to show how to solve a culture-related design issue.

A culture-related example Let us observe a pattern example by a culture-related problem. The *Strategy* Pattern (Gamma et al., 1995, p. 315-323) makes it possible to select the algorithm to execute a determined function at runtime. Its main characteristics are the following:

- **Intent**: "defines a family of algorithms, encapsulate each one, and make them interchangeable. Strategy lets the algorithm vary independently from clients that use it."
- **Motivation**[2]: Consider a multiple language text editor, with text writing support for different scripts and writing systems, such as English's, Standard Chinese's or Arabic's. Some text handling functions, such as word segmentation or hyphenation, differ with respect to the language's writing system. In some cases, such as the Mandarin or Japanese, these functions need to solve particular issues[3].

  Different algorithms are needed to compose text in these different languages. Hard-linking each algorithm in a text editor makes the system structure rigid and difficult to maintain. The *Strategy* pattern offers a more flexible option, and makes it possible to select the algorithm at runtime, from an object family.



- **Structure**:

[2] Gamma et al. (1995) illustrate the *Strategy* pattern' motivation through an example of algorithms for breaking a stream of text into lines. We propose another text handling example, related with the possible differences found in the writing systems of different cultures.

[3] As it is briefly described in Section 7.1.1

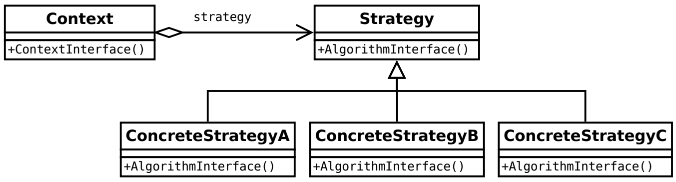


Figure 6.1: The Strategy pattern's Class structure

- **Participants**:
  - **Strategy** (Compositor): declares an interface that is common to the implemented algorithms. **Context** calls the algorithm defined by a **ConcreteStrategy** through this interface.
  - **ConcreteStrategy** (EnglishCompositor, ArabicCompositor, MandarinCompositor): implements the algorithm that is used through the **Strategy** interface.
  - **Context** (Composition): uses an algorithm defined by a **ConcreteStrategy** object. It keeps a reference to a **Strategy** object and may define an interface to allow **Strategy** access its data.
- **Consequences**: The main consequences of the this pattern are, among others: (1) It offers an alternative to directly subclass from **Context**, making it easier to maintain and upgrading the tool. (2) Strategy provides different implementations of the same behavior. The clients can easily choose among them. (3) Strategy increases the number of objects composing an application.

6.1.1 User Interface and User Interaction Design Patterns

According to a CHI'01[4] discussion panel on design patterns (Borchers and Thomas, 2001), Alexander's approach has been applied on Human-Computer interaction since 1986. However, they gained popularity a slightly before 2001. Since then, several approaches have been proposed, covering different aspects of HCI design, described through different methods, from informal narrative languages, to model- or XML-based formal approaches.

We have classified such approaches with respect to two different criteria: (1) the degree of formality in which they describe the solution part and (2) the design perspective (e.g. a concrete design level or different levels of a model-based architecture).

[4] Annual Conference on Human Factors in Computing Systems

Narrative solution - Concrete perspective patterns: Tidwell[5] proposes a language for describing desktop *standalone* tools following a narrative method. Van Weli (2001) proposes Task-based design patterns and provides some examples of concrete solutions. However, he identified the need of patterns are focused in what is currently as model-driven architecture. Van Welie also proposes an on-line catalogue of web solution-based patterns[6] In this classification we also find Borchers (2000), who proposes some musical design patterns, and Denef et al. (2011) who describes a pattern language for ubiquitous computing design, focused on front-line firefighting practice.

Formal solution - Model-driven perspective patterns On the other hand, Paternò (1999) has proposed the development of two types of interrelated Patterns: task and architectural. Task patterns are based on a high abstraction level, and the solution is mainly described through Concur Task Trees, previously presented in Section 5.1.2. Architectural patterns, focused on interaction components. Trætteberg (2002)'s perspectives include the development of design patterns that describe the solution through the models exposed in his Ph.D dissertation (RML, TaskMODL and DiaMODL). Radeke and Forbrig (2007) and Vanderdonckt and Simarro (2010) aim to integrate model-based approaches and design patterns.

6.1.2 Summary

Design patterns are reusable solutions to specific problems. Those solutions must be abstract and generic descriptions, independent of concrete specifications and computing technology. Gamma et al. (1995)'s Design Patterns are focused on object programming and they are mainly focused on the computer part of the system.

According to our interpretation of the Trætteberg (2002, p. 182)'s conclusion on *design patterns*, the information given by the patterns should show how to move between the high-level problem-oriented design models (such as those in the CIM) to the concrete solution-oriented design models (PSM).

In object-oriented programming there is a mature unified approach and a catalog of design patterns, introduced by Gamma et al. (1995). While in the scope of human-computer interaction design, there are several proposals to describe patterns that cover different aspects of user interface design.

[5] Tidwell, Jenifer. Common Ground: A Pattern Language for Human-Computer Interface Design `http://www.mit.edu/~jtidwell/common_ground.html` (Last modified version: May 17, 1999)

[6] `http://www.welie.com/` Accessed on October 3th, 2012.

Theoretical Consideration 6.1. *To our understanding, unlike object-oriented programming, the human-computer interaction domain lacks a unified method to describe design patterns. Nevertheless, we can observe progress in that direction, e.g. the works of Radeke and Forbrig (2007) and Vanderdonckt and Simarro (2010)*

6.2 Design Rationale

The previous section provided a brief description of *design patterns*, which structure the design information about specific issue-solution couples. Compared to design models exposed in Chapter 5, design patterns provide additional information concerning the motivations to solve the issue, and the consequences of applying a determined solution.

However, if we consider the structure shown in Section 6.1, the information regarding the design process, the decisions, alternative solutions and the rationale in general, is informally given in non-exclusive pattern components. This kind of information can be expressed in the **Motivation** and the **Applicability** pattern elements, but the arguments and decisions to choose the solution described by the pattern are not explicitly exposed.

In this section, we present *design rationale*, a documentation method that aims to describe the arguments, alternatives and decisions behind a design process. It was initially introduced by Werner and Rittel (1970) to structure the argumentation process to resolve *wicked problems*. According to Moran and Carroll (1996), design rationale refers to express the actual reasons for the design. There are different *design rationale* approaches, such as Issue-Based Information System (IBIS) and Question-Options-Criteria (QOC), among others.

Issue-Based Information System (IBIS) was developed to support coordination and planning of political decision processes. IBIS aims at guiding the identification and structuring of *issues* raised during problem-solving. Werner and Rittel (1970) initially developed IBIS for the government and public policy although its use has been extended to other decision-making environments, including software design.

Question-Options-Criteria (QOC) With similar goals than IBIS, Question-Options-Criteria (QOC) was proposed by Maclean et al. (1989) as a representation of design processes. QOC provides a semi-formal notation to structure the different *options* (design alternatives) and their evaluation *criteria* to answer a *question* (design issue). In other words, QOC provides a structure to represent the relationships between three elements that take part during a design solution: the *question*, the *option* and the evaluation *criteria*. Additionally, MacLean et al. (1996) includes an argumentation base, expressing the *arguments* to evaluate each *option-criterion*. This approach should be called *Questions-Options-Criteria-Arguments*.

Figure 6.2 shows an example of the notation proposed by QOC.

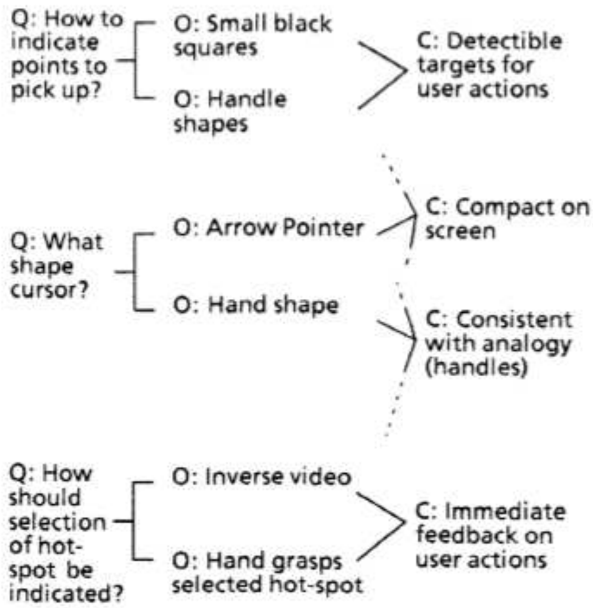


Figure 6.2: Part of a Design Rationale comparing different options to solve some Questions. Taken from MacLean et al. (1991)

Figure 6.3 summarizes the relationships between some *options* and the evaluation *criteria*.

CRITERIA

OPTIONS	Low Effort	Screen Compactness	Continuous Feedback
Appearing	−	+	−
Permanent	+	−	+

Figure 6.3: The relationship between two alternative Options and the Criteria to evaluate between them. Taken from Maclean et al. (1989)

As a complementary tool, Janeiro et al. (2009) propose to make use of QOC to enhance the *design pattern* information. In the scope of user-interface model-drive architecture, García Frey et al. (2011) consider a model based on QOC to represent the *design rationale* in the UsiXML framework.

Theoretical Consideration 6.2. *Design rationale methods, such as QOC, can be used to document the information regarding the decisions taken to select a solution among different alternatives.*

We think that cultural-characteristics can be part of the argumentation base to make design decisions, and it is important that such arguments can be used in further design processes.

6.3 Summary

This chapter has given a summary on two design description approaches: *Design Patterns* and *Design Rationale*. *Design Patterns* aim at describing reusable solutions to known problems, through a semi-formal structure. The aim of *Design Rationale* is to expresses the reasons, decisions and arguments behind a solution to solve a design issue.

We believe that these are two complementary tools. We can consider the components of the QOC model —question, options and criteria— into the design pattern structure. The *question* in QOC is already explicit in the pattern: it is equivalent to the design issue it aims to solve. A new *options* element can provide additional information that the *motivation* already does. And describing the *criteria*, we can provide an evaluation of the options. This evaluation can be graphically represented as in Figure 6.3.

Theoretical Consideration 6.3. *We consider that design patterns and design rationale are complementary methods that may enhance design modeling information.*

Theoretical Consideration 6.4. *As Trætteberg (2002, p. 4) states, design patterns "provide guidance for how to move within the design space." However, in order to do that, design patters must consider the different design abstraction levels, and therefore, the information provided by user-interface design patterns must be enhanced by model-driven methods.*

Part II

Contributions

Chapter 7

A Model of Culture to design educational computing tools, and its application to the Nasa people

As we indicated in Chapter 3, Nancy Hoft affirms that modeling is a tool that contributes to the study of the users' culture. Thereof, we have selected the development of a cultural model as support for answering the question: "*What should we study about the users sociocultural context if we need to develop pedagogical computer tools?*" This chapter present our approach to model the users' sociocultural context and its application to the Nasa people.

The cultural model presented here is based on the work of Kluckhohn and Strodtbeck (1961), Hall (1989, 1990), Victor (1992), Hofstede (2005), and Trompenaars (1993). All of these works are briefly described in Chapter 3. As we have stated before, each of these models was conceived with a specific goal, according to the author's particular needs. For instance, Victor's *LESCANT* model helps to determine the main aspects of culture that affect business communication. Hofstede's model studies the patterns that form a culture's mental programming. Trompenaars' model helps to determine the way in which a group of people solves problems, etc.

Analysis criteria to select cultural characteristics: Of course, in the scope of the thesis we need a model to abstract cultural characteristics relevant to the development and design of educational computer tools. To outline our modeling proposal, we have compared the variables presented by the existing models listed above with our experience and knowledge about the Nasa people and the development of computer tools. We have selected the variables according to the following analysis criteria:

1. Cultural elements with a possible impact over the production of signs, that could serve as signification objects, concepts to construct metaphors, or determine characteristics of interface signs.

   As we have indicated in Chapter 4, our vision of Human-Computer Interaction could be defined through the metaphor: HUMAN-COMPUTER INTERACTION IS A COMMUNICATION PROCESS BETWEEN SYSTEM USER AND DEVELOPER. In a similar approach, de Souza (2005) affirms that Human-Computer Interaction is a communication process between (a deputy of) the system developer and the user. This communication process takes place through signs, such as graphical icons, words, clicks, gestures, sounds and a wide range of user-system interface components. As we state in Chapter 4, the interpretation (meaning) of those signs largely depends on the user's sociocultural background, and therefore, the signs that compose the interface have to be designed in accordance with the users' specific cultural context. The cultural model must help us extract from the users' sociocultural context, the elements that influence the interpretation of the signs, or that might serve as *objects*[1] for the elaboration of interface signs or metaphors.

2. Social conventions, institutions and other sociocultural aspects with possible influence over development, design and evaluation methods.

   Researchers such as Winschiers-Theophilus (2009), Gorman et al. (2011), and Medhi et al. (2006) describe their work in Namibia, Ghana, and Bangalore respectively. They illustrate how social conventions, common behaviors, available resources, among other factors from the sociocultural context, might influence computer tool development methods. Let us give three examples that might better illustrate these statements: (1) they report that, in these collective societies, evaluation methods are more fruitful when run in groups. (2) Feedback given by the users depends on how they perceive the developers/evaluators' status. (3) According to Winschiers-Theophilus's description, Namibian users tend to give an expected answer rather than what they really think about the tool.

3. Cultural values impacting the assessment of computer tools, or quality criteria.

   Winschiers-Theophilus also affirms that inter-cultural development processes must consider the way in which societies evaluate computer tools,

[1] *Object,* as one of the signs components, according to Pierce's semiotics theory Peirce (1931-1958)

> since the evaluation of computer technology is influenced by intrinsic "Western" values, under premises believed to be universal. For example, usability is considered equal to effectiveness, efficiency and satisfaction and it is measured in terms of task completion time. Winschiers-Theophilus argues that cultures have different value systems, and the criteria taken into account to evaluate software may be different. For example, she has concluded that Namibian users have a "deviating understanding of usability from the commonly assumed one (Winschiers-Theophilus, 2009, p. 665)."

According to these criteria, we have chosen a subset of relevant variables presented through classical culture models, adapting related dimensions according to our goal. These five dimensions, that we will develop in the rest of the chapter, are the following: (1) *Written and Oral Language*, (2) *Spatial structures*, (3) *Environment and Technology*, (4) *Social Organization* and (5) *Nonverbal Signs*. It is important to say that, from our point of view, these variables are interrelated and there is not a clear limit between them. They depend on each other and should be studied as a whole.

An initial modelling process results in a set of conclusions and hypotheses related to the development of computer tools. The first are exposed in this chapter, and the hypotheses validation will be described in the following chapter.

To summarize, the goal of this cultural model is to guide computer tool developers to ask themselves relevant questions regarding Nasa users' sociocultural context and to develop pedagogical computer tools. This chapter is divide in two parts. In the first one, we develop the cultural model, independently of the sociocultural context. In the second part, we apply the model to study the Nasa culture, and consequently, we formulate hypotheses and conclusions regarding the design and development of computer tools for such population of users, focusing on their education needs.

7.1 A sociocultural modeling approach

7.1.1 Written and Oral Language

For simplicity, the term *language* will apply in this thesis to the human written and oral communication systems. Other methods of expression and signification will be dealt with further on in this chapter. In the scope of our thesis, considering the users' language is essential. It is a common and prevailing point of study of a culture, and as David Victor stated, "it remains the most obvious difference that international business communicators are likely to face" (p. 15). Similarly, in the field of software localization (adaptation to different cultural contexts), most important efforts are generally concern language support. As Hoft (1996, p. 46) affirms, language is easily visible compared to other cultural characteristics, and most software localization processes take it into account, at least at a translation level.

To be more precise, written language has a prevailing place in computer technology and human-computer interaction. Let us observe that industrialized societies are literate, and written language is built-in on computer technology and interaction with the user. Programming languages are also written. The first version of the Fortran language was based on punched cards and most of modern programming languages use a kind of writing system based on Latin script.

In human-computer interaction, written language needs to be handled and "understood" by both the computing system and the user, and the diverging characteristics of different languages are important. We need to consider how languages differ in aspects such as: scripts, directionality, alphabet order, text segmentation, among others.

Existing writing system and scripts: As far as we know, Unicode offers the most complete support for (computational) representation and text handling in computing systems (The Unicode Consortium, 2012). As of 2012, the most recent version of Unicode, 6.1, contains 110,116 characters, covering more than 100 scripts of the world's existing written languages.

Unicode offers a wide panorama of the implications of multi-lingual support in computer technology. Besides character encoding and among other aspects of text handling, Unicode also covers a large amount of information with reference to word segmentation and line breaks; text sorting; correct displaying of text in right-to-left languages; time and date formats, and other elements appropriate to different locales; among other aspects of text handling. Let us consider the cultural influence on some of them:

Directionality: Besides the correct orientation of text, other characteristics of user interfaces depend on the language writing directionality. Traditionally, computer interface components are structured from left to right and top to bottom, as are the writing systems of Romance and Germanic languages. As argued by Khaddam and Vanderdonckt (2010), computer interfaces in right-to-left writing contexts, such as Arabic or Hebrew, must be disposed in a consistent orientation. This applies not only to text direction, but also to menu disposition, to the arrangement of text and icons in buttons, to windows layouts and to other graphical components. Figure 7.1 shows an Arabic graphical interface screen-shot, where the orientation of the graphical elements is consistent with the writing flow.

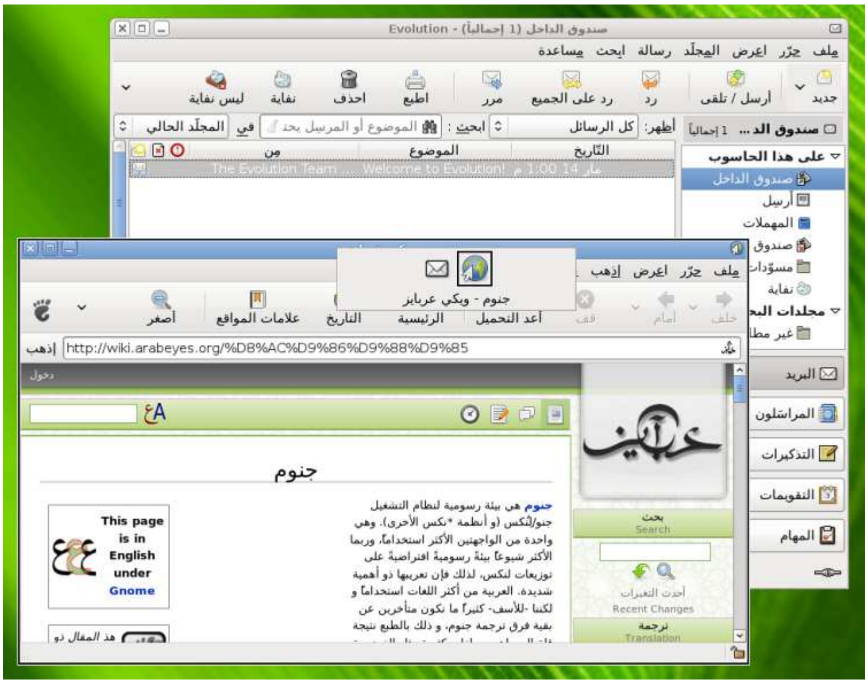


Figure 7.1: Screen-shot of the Gnome environment system localized for the Arabic context. Note the right-to-left orientation in windows layout, buttons, menus, etc. Credits to gnome.org[2]

Medhi et al. (2006, p. 40) reports a directionality-related issue when developing a user interface for illiterate domestic laborers in Bangalore. The tool's Muslim users misunderstood the information related to the work schedule, that was disposed in a left-to-right disposition. Developers had to explicitly indicate the reading direction of the message they were sending.

Another example of directionality-related issues is given by Ito and Nakakoji (1996, p. 105). They describe the change suffered by the Japanese writing-system when word processors arrived to Japan, bringing with them European-U.S. American writing machine metaphors and a left-to-right top-to-bottom writing direction. Today, the Japanese writing direction is the same as in English.

Alphabet order and collation: Languages have specific and distinct, or even non-existing collation rules. This is important because alphabet order and other sorting criteria are used, for example, to arrange elements or information in the interface. Collation differs across languages even when they share the same script: Latin script-based languages present different rules as they use digraphs or diacritics. The Unicode Consortium considers this through the Unicode Collation Algorithm, which gives a clear example:

> "in the majority of Latin languages, ø sorts as an accented variant of o, meaning that most users would expect ø alongside o. However, a few languages, such as Norwegian and Danish, sort ø as a unique element after z. Sorting "Søren" after "Sylt" in a long list, as would be expected in Norwegian or Danish, will cause problems if the user expects ø as a variant of o[3]."

Thus, it is important to note that languages have different sorting criteria, and they do not always have a standardized alphabetical order.

Text segmentation: According to Jin and Chen (1996, p. 151), *tokenization* and *segmentation* are basic processes needed to support natural language processing and graphical text display. They define *tokenization* as the process through which a word is broken into characters and *segmentation* as the process through which a sentence is broken into words. Both processes rely largely on word delimitation. Identifying delimitation marks, such as blank spaces, hyphens or slashes, allows us to implement correct text display or editing features in tools. According to Jin and Chen, for the writing systems of most European and some Asian languages, these processes are almost trivial, because word boundaries are always explicit.

However, for languages such as Japanese or Chinese, tokenization and segmentation are difficult because: (1) there is no explicit word delimitation, (2) "some substrings in a sentence may actually be a word" and (3) there are different ways of segmenting a word, each resulting in a different meaning.

To summarize, the following are examples of language-related variables to be studied given their possible influence computer tool development: oral versus written base; existing writing system and scripts; alphabet structure; alphabet normalization; alphabetical order; character computing representation support; writing direction; political or social policies that influence the language or the use of a writing system; words segmentation; and computer-related vocabulary.

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[2] `http://library.gnome.org/misc/release-notes/2.20/figures/rnusers-arabic-window-switcher.png` Accesed on July 27th, 2012

[3] http://www.unicode.org/reports/tr10/ Accessed on August 24th, 2012

From the three analysis criteria that we have used to select cultural characteristics, it seems that written and oral language have their place mainly in the elaboration of the interface signification system.

7.1.2 Spatial structures

This variable pertains to the ways in which cultures conceive, use and structure spaces. In general, this dimension deals with undeclared rules about personal distancing and laying out lands, houses, towns, etc. As described in Section 3.4.1, Hall divided the Space dimension in four categories: *Territoriality*, *Personal Space*, *Multisensory Space*, and *Unconscious Reactions to Spatial Differences*. Insofar as our goal is concerned, we are interested in the possibility of providing the users with social interaction spaces similar to those defined by their culture. We pay attention to two space-related aspects: (1) interface metaphors based on space structures and (2) the use of space in the interaction with computer tools.

First, we are interested in the elaboration of interface signification systems, taking into account their individual and/or collective use, according to social conventions. We need to consider the possible individual and collective spaces, as well as the conventions governing them. This implies that space is strongly related to aspects of Social Organization, such as collectivism vs individualism (See Section 7.1.4).

Second, we think it is important to consider the place of computer tools in the different spaces where the users interact, including the boundaries of personal spaces and other "territories."

As their name says, Personal Computers have an implicit personal orientation, also visible in interface components: Personal Computer, MY DESKTOP, MY DOCUMENTS, MY NETWORK PLACES, etc. Is it possible to elaborate metaphors and design the interaction according to space structures established by the users' culture?

On the other hand, as argued by (Greenberg, 2011), inter-personal distancing rules can be applied to the design of collaborative digital surfaces (or other ubiquitous computing devices).

As a manner of summary, the following are examples of cultural variables that help to study this spatial dimension: individual and collective spaces; spatial declared or undeclared boundaries; and spatial structuring governing rules.

7.1.3 Environment and Technology

This dimension studies the nature of the environment and the technical resources available in the places where people live and work, as well as their place in society. This dimension is mainly based on the model of Victor, who defines *environment* as "the physical elements—both natural and human-made—that surround a person. These elements influence, on the most fundamental basis, the way each person understands the world around him or her" (Victor, 1992, p. 46).

We are also interested in the computer literacy and skills of the Nasa users, particularly in the case of students and teachers. David Victor states that people adapt to the natural world that surrounds them, and, in doing so, they define an essential part of the culture. According to Victor, environment is the building block where culture is constructed.

As far as our objective is concerned, functional and non-functional requirements partially depend on the availability of computing and technical support, as well as on common resources found in the users' sociocultural context. Therefore, different aspects of this dimension interest us:

Electric power supply. Electricity is essential for the use of computer technology and we have to take into account that it is not always available. In 2005, 93.6% of Colombian households had electric power (DANE, 2005, p. 465). El Cauca is below average: 74.56% of all of the houses in the department were connected to the electricity grid[4].

Prevailing environment and daily-life resources. Common toys and recreational tools. Desktops, files, folders, recycle bins and other elements common in offices are part of the main personal computer interface, initially designed for users familiar with office environments. In similar manner, we need to look for objects that could serve as interface signs for Nasa users. Familiarity is needed in order for a sign or a metaphorical concept to be properly interpreted.

Computer resources available. Each society has different access to personal computers, mobile phones, TVs, DVD players, radios, etc. Tool development possibilities depend on the computer resources available. Depending on the context, technical resources other than personal computer or even other

[4] Unidad de planeación minero energética (UPME) `http://www.upme.gov.co/generadorconsultas/consulta_series.aspx?idmodulo=2&tiposerie=128` Queried on August 26th 2012. We were unable to find specific values for urban and rural areas.

than more complex devices can be more suitable as supporting platforms. For example, Gaikwad et al. (2010) have developed interactive educational tools to be used on television sets and DVD players, especially designed for rural areas in India, where these devices are more often available than personal computers.

It is important to study what is the ratio of computers, mobile phones and other devices by number of people. According to Colombian official statistics, in 2011 37.1% of urban and 4.9% of rural households had a personal computer, while the values regarding the number of people who owned a television set were higher: 92.6% and 78.6%, respectively to urban and rural areas[5].

Networking and Internet access. It is important to determine whether the system can be supported on computer networks or not, whether it could be an on-line tool (websites, for example), or whether standalone applications are more suitable. What are the Internet access conditions? Do they have access to Internet connection? Is it reliable? Is it permanent?

As a manner of example, Colombian Official statistics report an important gap between the number of urban and rural households connected to internet: 29.5% and 2.4%, respectively[7].

Computer skills and literacy. Who would give technical support once the tool is deployed? What are the computer skills of teachers and users?

7.1.4 Social Organization

David Victor broadly defines this variable as the common institutions and collective activities shared by members of a culture. According to Victor, social organization influences people's behavior in all aspects of life, including communication processes in business. Under the premise that HUMAN-COMPUTER INTERACTION IS A COMMUNICATION PROCESS, the users' social organization also influences the use of computer tools. Likewise, we think that these common institutions impact the computer tool development process.

Social organization must be taken into account to determine system functional and non-functional requirements, such as cooperative work capabilities

[5]Departamento administrativo nacional de estadísticas (DANE) - Boletín de Prensa, Indicadores básicos de tecnologías de información y comunicación –TIC para Colombia. Año 2011. Available at: `http://www.dane.gov.co/files/investigaciones/boletines/tic/bol_tic_2011.pdf` Accessed on September 2nd, 2012

and its governing rules. It must also determine aspects of the development process, like the collective involvement of the users during design and evaluation stages, or the policies that enable communication with the community. Examples of aspects of Social Organization to be considered include the following:

Individualism vs Collectivism As described in Section 3.3.2, Hofstede's concept on individualism versus collectivism studies the relationship between the individual and the collectivity. It explores interpersonal ties and social cohesion. In Trompenaars' model, this dimensions is related on how people perceives themselves, primarily as individuals or as members of a group.

As described by Medhi et al. (2006), Winschiers-Theophilus (2009) or Gorman et al. (2011), in societies with a prevailing collective orientation, design and evaluation methods give more fruitful results when they involve group of users, rather than single individuals.

Authority institutions and social roles It is worthwhile to question the existing rules or institutions that influence the approval of the development of computer tools, their use and prototype evaluation methods. As Winschiers (2001) has observed in Namibia, or Clemmensen and Plocher (2007) in European-Indian teams, feedback given by users depends on how they perceive the evaluators' position. For example: " in Malaysia having a test user of higher rank than the experimenter will result in more negative comments about the product than having a test user of lower rank than the evaluator. In some countries testing subjects individually should be avoided, as little information may be retrieved"Clemmensen and Plocher (2007, p. 267).

Also, it is important to take into account authority and social roles in task execution, especially in multi-user systems. User interaction through the interface may be designed according to governance rules.

Educational system, methods and needs. The place of computers in the classroom and curriculum. If we aim at developing computer pedagogical tools, we think it is important to consider the curriculum, the education policies, the needs and other aspects of the user's education system.

As shown in the following section, pedagogical needs can play an important role in defining interface (signs) concrete characteristics.

Work organization If several users are involve in the same task, rules, methods, roles and work organization may be important. In this case, we think it is important to study how should computer-supported cooperative work be organized.

Value given to time Cultures value time differently, and this affects the computer tool evaluation criteria. As Lakoff and Johnson (2003, p. 9) metaphorically describe it, TIME IS MONEY for Western cultures, which place a high value on time. Winschiers-Theophilus (2009, p. 666) claims that task completion time is one of the main criteria for measuring software quality in Western societies, but it is largely irrelevant in the Namibian context.

7.1.5 Nonlinguistic signs

In this cultural dimension we study non-written and nonverbal signs that take part in the communication process between the developer and the user, who communicate through the interface. This dimension is based on Victor's concept that deals with the exchange of information through nonlinguistic signs, described in Section 3.4.2. In the realm of international business communication, Victor identified several categories of nonverbal information exchange, divided in two types, *active* and *passive*, according to the control the individual can have over them (Victor, 1992, p. 185). In the scope of our thesis, we wish to highlight and give examples of several kinds of nonverbal signs that may be part of the signification system:

Colors: cultures assign different meanings to colors. Particular color-meaning associations are believed to be universal (e.g. green is "go" and red is "stop"). Nevertheless, it is important to consider the possible implications that the colors used in the interface could have.

As in any other communication media, colors may have established meanings in interfaces. Red, for example, is associated with terminating processes, exiting a user session, closing a window, and other similar actions. Figure 7.2 shows an example of how a red octagon, as an analogy to the Stop traffic sign, is used in the cancel buttons design in dialog windows.

Numerals and counting indicators. Hindi-Arabic numerals[6] are the "closest we come to a universal system of communication (Victor, 1992, p. 220)." However, their use varies according to cultures. For example, decimal and number segmentation differs in Colombia, France, USA and Japan, where the same quantity is written in different formats: 1.000,23 1 000,23 1,000.23 1000,23.

It is important to bear in mind that there are also other numeral systems,

[6]Hindu-Arabic numerals are also known as Arabic numerals. However, Flegg (2002, p. 67) affirms that current decimal numerals "derived from forms which were invented in India and transmitted via Arab culture to Europe."

Figure 7.2: Screen-shot of New Image option in Gimp, GNU Image Manipulation Program.

such as the Devanagari (Hindi) system, the Chinese system, the Japanese system, the not-longer used Mayan system or the different versions of Hindu-Arabic system.

Computer systems and interfaces must take this into account for a correct handling and graphical representation of quantities. The Unicode standard includes, in the different scripts, numeral systems and the given formats (The Unicode Consortium, 2012).

Numerals and counting indicators are strongly related to written language. However, we have decided to include them in the category of nonverbal signs because (1) Victor describes other non-written methods to express numbers, such as finger-counting. (2) Numbers can be assigned special meaning and this can be taken into consideration while designing the interface. We will study an example that illustrates this case in the Nasa culture.

Shapes, emblems, devices, tokens or other meaningful graphical signs. Interfaces are full of abstract symbols that were arbitrarily attributed a meaning by computer developers, inspired in some cases, from objects from the real world. For example: arrows, pointing hands to indicate the MOUSE pointer position; lifebuoy to ask for documentation or help about the use of the system; and traffic signs, such as the red octagon meaning cancel, shutdown and other actions as described before.

Figure 7.3: Graphical symbols in interfaces. Taken from the GTK+ graphical library.

It is to be noted that traffic signs are not universal. The wrong way symbol, meaning here wrong manipulation or other errors, is not used in Colombia, where road directions are indicated with arrows at each corner. The red octagon stop sign is also different in countries such as Japan or Ethiopia (See Figure 7.4).

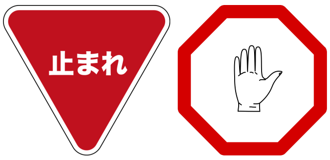


Figure 7.4: Japanese and Ethiopian stop traffic signs. Credits to `http://en.wikipedia.org/wiki/File:Japanese_stop_sign.svg` and `http://en.wikipedia.org/wiki/File:Ethiopian_Stop_Sign.svg`

Preferences in respect of graphical representations. This concept is not included in Victor's model. It arises from observations concerning the favorable reception of computer tools including complex graphical representations or abstract ideas. We consider this to be one of the software evaluation criteria.

Medhi et al. (2006, p. 39) have developed a Text-free user interface for illiterate users in Bangalore slums. She has found that users understand semi-abstract images and "photorealistic" graphics much better than complex abstract representations. Medhi et al. suggest carrying out frequent iterations with the target community to make sure that the meanings conveyed by the interface signs are meanings that the we intended.

7.1.6 Section summary

In this section we have presented the five cultural dimensions of our approach to model the users' sociocultural context to design pedagogical computer tools. In the next part of this chapter, we present the application of this model to characterize the Nasa culture. This process will result in the formulation of a set of design conclusions and hypotheses, whose evaluation will allow us to confirm or refute this cultural model.

Furthermore, now that we have described the five dimensions of our cultural model, we can formulate the general research hypotheses of this thesis:

Thesis' general research hypothesis 7.1. *The interactive tool design models and description methods considered in this thesis can describe the culture-design consequences identified through the modeling of the users' sociocultural characteristics.*

In other words, this hypothesis will make it possible to establish the relationship between the sociocultural and the interactive design models. Consequently, the validation of this hypothesis has a twofold requirement in the context of our thesis: the application of the cultural model to the Nasa culture and the computer tool design modeling aimed at Nasa children.

7.2 The sociocultural model applied to the Nasa case

This section shows how the model previously described is applied to study and characterized the Nasa sociocultural context.

7.2.1 The Nasa language and human-computer interaction

Script, history and direction: As we have said in Chapter 2, the Nasa language is called Nasa Yuwe. Its alphabet is relatively new, the Nasa people agreed to the use of a writing system for their mother tongue in 2001. The Nasa Yuwe alphabet, shown in Table 2.1, is the outcome of the unification process of three different proposals. The first attempt to write Nasa Yuwe was strongly based on Castilian Spanish. As a consequence, the two writing systems share at least two characteristics: the same direction (left-to-right and top-to-bottom) and a script based on Latin characters.

User interaction media: Being part of different languages, the writing systems of Spanish and Nasa Yuwe present important natural differences. For example, there are two types of characters that do not occur in the Castilian alphabet: the letter ç and the nasal vowels, the latter represented by the tilde diacritic (˜). These characters also lack on Spanish keyboards, which are the most common in Nasa territory. Therefore, we can conclude that:

> **Design Conclusion:** an alternative has to be included in the interface so that Nasa speakers can use their own language when using personal computers.

Let us observe that this conclusion is related with the Environment and available technology dimension (Section 7.2.3): about the computer resources found in the Nasa context, text input media or keyboards in this case.

Encoding and graphical representation support: Issues related to encoding text data are, hypothetically, solved by the Unicode standard, which, as we have mentioned above, aims to cover any written language in the world. Another encoding system common in Spanish-speaking contexts is ISO-8859-1 (Latin-1), however, it lacks support for three of the nasal vowels, only covering the ã letter. Thereby,

> **Design Conclusion:** The use of Unicode UTF-8 in the Nasa Yuwe context is mandatory to be able to handle any Nasa Yuwe grapheme.

Alphabetic order: At present day, there is not consensus regarding the alphabetical order for the Nasa language[7]. Nevertheless, for literacy processes in schools, the alphabet is divided in several groups of letters: students begin with the vowels followed by groups of consonants: p, t, ç and k; then, m and n; in turn b, d, z and g; and so on.

> **Design Conclusion:** The question concerning the order of the elements in the interface according to the alphabet is still unanswered.

Note the 4-2-4 sequence found in number of letters during the process of learning consonants. We will describe the place of this sequence in the design of interface elements when we detail the Nonlinguistic signs (Section 7.2.5).

Computer-related vocabulary: As far as we know, Nasa Yuwe does not have its own computer-related vocabulary. Twelve main terms where proposed and successfully evaluated in 2006 (Checa Hurtado and Ruano Rincón, 2006) but they have not been appropriated.

[7] Personal communication with Tulio Rojas Curieux, 2012

Pedagogical needs: According to Nasa authorities, the number of Nasa Yuwe speakers is decreasing. Nasa Yuwe is an endangered language, and people prefer to speak in Castillian rather than in Nasa Yuwe. As we shown in Section 2.2.2, Nasa authorities aim to revitalize the Nasa language through bilingual education provided by the PEBI.

If we take into account the Nasa Yuwe alphabet structure, we can observe:

> **Design Conclusion:** As stated by Tulio Rojas Curieux, one of the pedagogical needs in literacy teaching is the identification of digraphs and trigraphs as phonetic units.

7.2.2 The Nasa spatial structures and their possible impact on human-computer interaction

As described in Section 2.1, Nasa social interaction spaces are seen by Nasa leader and teacher Mincho Ramos as a spiral that grows around the house's three-stone hearth (*tulpa*). We have previously described the relevance of the *tulpa* as the center of family life, and a place to meet friends and learn from the elders (See Figure 7.5). This is the first (immediate) collective space for a Nasa person.

Figure 7.5: Picture illustrating a communal meeting around a *tulpa*. Image taken from the Universidad autónoma indígena intercultural's website `http://uaiin.org/` on August 28th, 2012

Following Mincho Ramos' concept of space, family spaces are circumscribed in the *resguardo*. Despite the possible internal divisions inside the Nasa territory, the *resguardo* represents the main and basic political unit of the Nasa people (Pachón C., 1996). Being the community territory, *resguardos* are a second collective space.

From this space structure, we can formulate the following design hypothesis, that, if validated, will serve as interface metaphor base concept for the

Nasa education computer framework.

> **Design Hypothesis:** Nasa evaluation users understand the interface metaphor that represents their spatial structuring (collective spaces centered on three-stone hearth)

Notion of space and vision of the World Cultures may have particular ways of conceiving and structuring space. In the Nasa culture, for example, the world is divided vertically in two sections: left and right. Elements, such as the sun, *Tays* (Energies), the *thẽ' wala* (Nasa healer), etc., are found on the left. Opposite elements such like the moon, disharmonies, cold plants, etc., are found on the right.

Energies move from one side to the other, causing disharmonies in energies and the cosmos. Harmony can be restored through the cleaning ritual, during which a *thẽ' wala* draws semicircles with medicinal plants, covering the body from the right to the left foot (See Figure 7.6). We hypothesize the application of this space concept in the design of computer interfaces:

Figure 7.6: *Thẽ' wala* performing a cleaning ritual. Credits to the CRIC. Image from the video "Nasa yuwe' walasa' - Nuestra lengua es importante" Consejo Regional Indígena del Cauca - CRIC (1996a)

> **Design Hypothesis:** Evaluation users understand the interface structuring according to their left-right World vision. (For example: output information regarding system failures or problems is arranged at the right of the

interface; input elements and actions to solve these issues are represented at the left of the interface).

7.2.3 The environment and technology situation in the Nasa context

Prevailing environment and common resources As we have said above, the Nasa environment is mainly rural, most of the Nasa population inhabits *resguardos* in the Andes Mountains, where they lead an agricultural life. At the same time, they state that they try to live in harmony with Nature (Cátedra Nasa Unesco, 2001b, Consejo Regional Indígena del Cauca - CRIC, 1996b), they feel part of it, just like any other being.

Among the different agricultural products, we would like to highlight the maize. This crop takes on special importance, as it is the very staple of the local diet and economy (Pachón C., 1996). Maize was previously used as main stimulus in a pedagogical game, yet it has some design issues because it was based on an exogenous game dynamic (Checa Hurtado and Ruano Rincón, 2006).

In schools, resources are rustic or scarce, therefore recreational tools and toys are build from materials found in nature (See Figure 8.3). We can formulate the following hypothesis, regarding local resources, that concern both design concepts that we will evaluate with the Nasa users:

Design Hypothesis: Computer interface metaphors based on common objects found in the Nasa context are meaningful for the Nasa users.

Electricity supply and computing support Some of the requirements according to which the communities concerned in this thesis were selected were power supply and the availability of personal computers. There are Caucan rural areas where electricity is partially present. For example, in 2009, in the municipalities of Inzá, Paez and Caldono (circumscribing 29 Nasa *resguardos* or communities), there were 1,934, 4,860 and 2,549 houses that were not connected to the electricity grid[8].

We also known, according to the descriptions made by Tulio Rojas Curieux and Abelardo Ramos Pacho, and thanks to the observations made in 2006 on

[8] `http://www.upme.gov.co/generadorconsultas/Consulta_Series.aspx?idModulo=2&tipoSerie=157` Total number of households in the municipalities is lacking.

the Pueblo Nuevo *resguardo*, that computer resources in Nasa contexts are scarce (Checa Hurtado and Ruano Rincón, 2006), and sometimes, they are provided by the Colombian government through salvaged material programs. Therefore, we can conclude:

> **Design Conclusion:** Tools developed for the Nasa people should not require high-performance equipment.

Networking and Internet access: As described in this section, Internet access and networking capabilities are limited. In the next chapter we will detail the situation in the concerned *resguardos*.

Technical skills and digital literacy: We will also describe computing skills and the literacy rate in the concerned communities in the following chapter.

7.2.4 The Nasa Social organization and its implication in HCI

Collectivism and work organization The value given to the collectivity in the Nasa culture is visible in at least two aspects: the communal ownership over *resguardo*s, and the work organization. As stated in 2.2, the organization of the collective work organization is based on different kinds of invitations to work. The Nasa people place a high value on the three different cooperative work methods. When the Nasa take part in collective activities, they claim that they are part of the community.

A *minga*, as the communal work party is name in Spanish[9], is called when the community needs to build a school, carry out farming activities, celebrate a marriage party Cátedra Nasa Unesco (2001a), make a decision on a political issue, or in any event where the community is involved.

Cooperative work is an integral part of Nasa life and it can be seen as a permanent or everyday activity. In some places, a certain day is assigned for communal work, e.g. Monday in Tumbichucue. Under this cooperative work orientation, we believe that a cooperative work-capable system would be suitable as education framework, hence, we hypothesize:

> **Design Hypothesis:** Nasa school users (teachers and students) agree in the design concept of a cooperative-work capable system based on Nasa social roles and invitations to work.

[9] In Nasa Yuwe, people say *pi'kx yat* (the minga house)

Collective assessment. In a similar manner to Medhi et al. (2006), Checa Hurtado and Ruano Rincón (2006) made initial observations concerning the collective evaluation of prototypes, which produced more fruitful results than individual evaluation methods or usability tests, such as *card sorting* or *talking aloud*. However, we think further evaluations to compare individual vs collective prototype assessment are needed, thus, we formulate the hypothesis:

> **Design Hypothesis:** Collective evaluation methods are more suitable than individual tests in the Nasa context. The community must be taken into account in the different stages of the tool development.

Authority institutions and user roles: in the scope of task execution in cooperative systems, we think that the user's role, whether as *cabildante* or not, could impact group participation in collective tasks completed through the interface. To outline this cooperative-work capable system-related requirement, we need to validate the hypothesis:

> **Design Hypothesis:** Evaluation users agree in the design concept and use of a cooperative work-capable system based on their work organization (*El cabildo* can invite the whole community users to take part in the collective tasks accomplished through the system, while all other *resguardo* inhabitants can only invite a limited group of people)

According to the authors' observations, authority institutions also play an important role in completing the computer tool development process. It is up to the *cabildo* to decide whether it is possible to work with a community or not. Therefore, we can conclude:

> **Design Conclusion**: Elders' or authorities approval is needed to carry out computer tool development projects

Educational policies and needs: As we have mentioned before, Nasa authorities explicitly stated the need to strengthen the Nasa Yuwe, and promote bilingual education in their schools (Consejo Regional Indígena del Cauca - CRIC and Rappaport, 2004, p 28). Seeing that students and teachers made positive appreciations regarding the previously developed maize game, we think that computer games are a good method to revitalize the Nasa language. Nevertheless, we need to confirm that recreational activities are part of the pedagogical strategies and methods:

Design Hypothesis: It is possible to propose new pedagogical games as far as recreational tools are part of educational strategies in Nasa schools

Pedagogical needs have also determined interface characteristics of *çut pwese'je*: in the on-screen keyboard, explicit buttons for Nasa Yuwe digraphs and trigraphs were included, as shown below in Figure 7.7. This is an alternative to the classic physical keyboard, in which, digraphs (e.g. Spanish letters ch and ll) can be written through the sequential combination of two keys. The *çut pwese'je* on-screen keyboard enables the user to input any Nasa Yuwe character by selecting a single button.

Figure 7.7: 69-grapheme on-screen keyboard designed for *çut pwese'je*

Another alternative to write in Nasa Yuwe is the use of complementary graphical tools composed of the 5 basic letters not present in the Spanish keyboard: ç, ĩ, ẽ, ã and ũ, as illustrated in Figure 7.8. However, even if the on-screen keyboard requires more graphical space, Nasa pedagogical needs primed to choose the design solution.

Figure 7.8: Alternative complementary graphical tool to input Nasa Yuwe letters lacking in Spanish keyboards

7.2.5 Nasa nonlinguistic representations and their possible place in the interaction

Shapes: As described in Section 2.5, Nasa culture places a high value on two meaningful interrelated graphical symbols: the rhombus-shaped *ũhza yafx* and the left-to-right spiral.

In Checa Hurtado and Ruano Rincón (2006), the authors described the importance of rhombus and of the spiral in *çut pwese'je* the maize pedagogical game (See also Ruano Rincón et al. (2010)). The game's main stimulus is a field of sixteen maize. In a early design, the maize were disposed in two rows of eight maize each. However, after the study of Nasa graphical representations, the maize were arranged in a rhombus-shape. According to an evaluation with a group of 30 users, it was found that the rhombus layout was a more suitable and more appreciated (Both game version are shown in Figures 7.9 and 7.10). As described in Checa Hurtado and Ruano Rincón (2006), the 30-people evaluation group reacted enthusiastically when they recognized the *ũhza yafx* in the game interface.

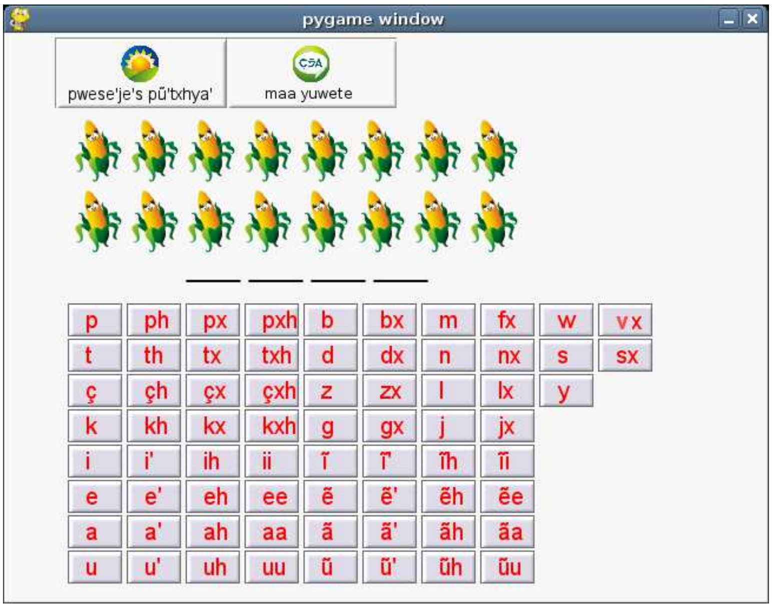


Figure 7.9: *çut pwese'je*, the maize game. Design prototype

The spiral, the other important Nasa shape, is also found in the maize field. As the player chooses letters that not occur in the hidden word, maize plants "disappear". To establish the sequence in which maize is removed from the game, two possibilities, shown in Figure 7.11, were proposed to the users. The

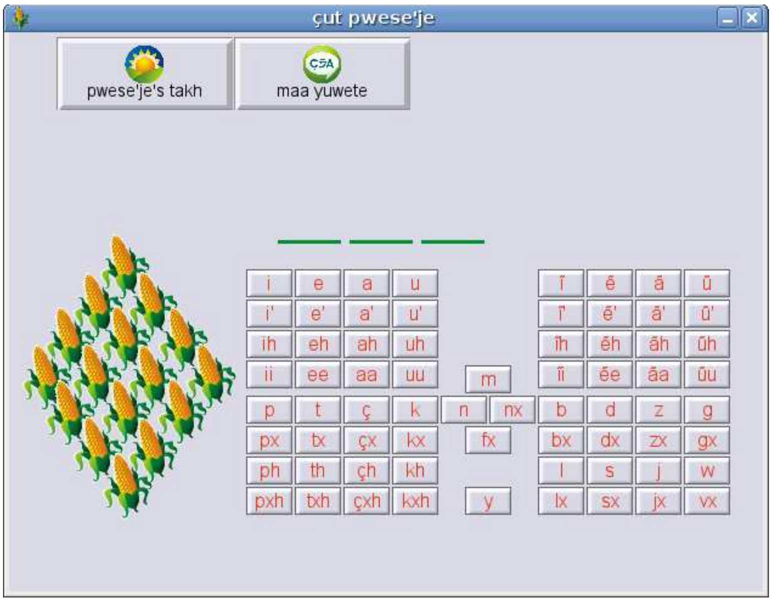


Figure 7.10: *çut pwese'je*, the maize game. Current version

first sequence removed the maize at the center first, continued with those in the middle of the rhombus sides, and let the four maize at the four corners for the end. Users said that "only a dog starts harvesting from the center; a good Nasa starts from the borders and finishes in the center". The second option, which draws a spiral as maizes are removed was selected by the evaluation group. Hence, we can consider the following conclusions:

Design Conclusion: The use of the rhombus shape in the interface highlights important elements and explicitly show the link with the Nasa culture

Design Conclusion: The spiral in the interface is associated with two interrelated meanings: (1) the development of processes and time-related events, (2) territorial expansion and the user's movements between the space of interaction (Refer to Hypothesis 3)

Preferences in respect of graphical representations. In Checa Hurtado and Ruano Rincón (2006), the authors state that Nasa users seemed uncomfortable with non-realistic or abstract images, where, for example the maize had eyes and a nose (Compare maize cobs in Figures 7.9 and 7.10).

Observations have also shown that the idea of "disappearing" maize is not understood. Various Nasa teachers have suggested that in the game, the

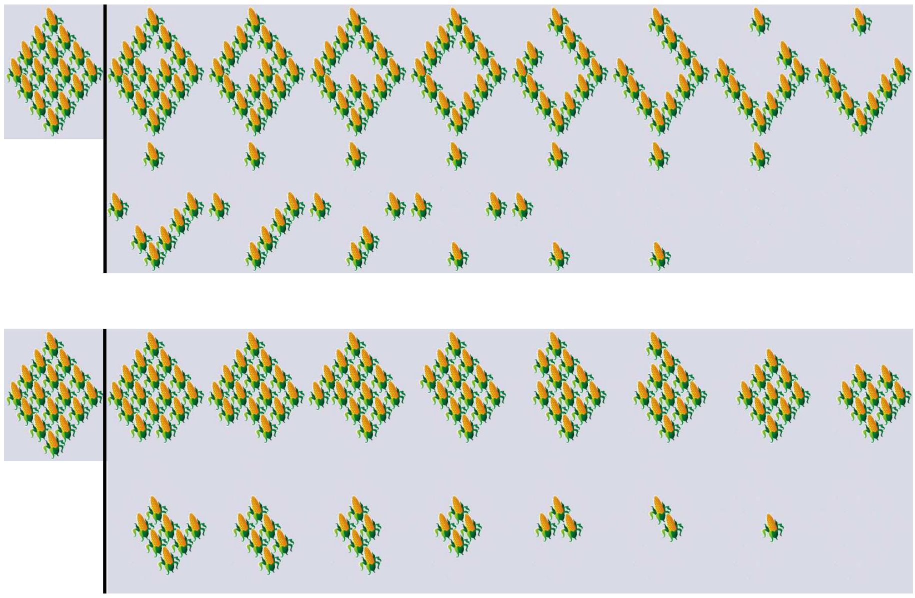


Figure 7.11: “Disappearing” maizes sequences.

maize should be stolen by a squirrel or a bird, as it happens in the real life.

> **Design Conclusion:** Nasa people feel uncomfortable with abstract ideas and images. Realistic interface images and concepts are better perceived than abstract or complex features

Numbers. In Section 7.2.1, we showed that the number of consonants learned at each stage of literacy teaching corresponds to 4-2-4-. . . : p, t, ç, k; m, n; b, d, z, g; etc. This sequence is inspired from the Nasa people’s vision of cosmos, represented in the ũhza yafx: four Great Beings, two world vertical divisions, 4 world levels, etc.

The keyboard found in Figure 7.10 was designed bearing in mind this numerical sequence: the base consist of 4x4 buttons blocks, where graphemes are divided according to the alphabet learning process.

Colors. (Lasso Sambony and Calambás Sánchez, 2005, p. 72) quote Teacher Macedonio Perdomo, who describes the following color-meaning relationships: blue-sky; green-nature; red-violence, blood; white-friendship; purple-engagement; black-darkness. Nevertheless, we have not identified relevant color-meaning relationships that should be taken into account in the interface.

7.3 Conclusions

In this chapter, we have described the cultural characteristics that were selected in order to study the Nasa culture and to develop pedagogical computer tools. These cultural characteristics are divided in five broad dimensions: (1) *written and oral language*, (2) *spatial structures*, (3) *social organization*, (4) *environment and technology* and (5) *nonverbal signs*. These dimensions are selected from comparative analysis between existing cultural models and the impact of different sociocultural contexts on human-computer interaction design. To evaluate the influence of culture on HCI, we have taken into account different previous studies, among them: Ito and Nakakoji (1996), Jin and Chen (1996), Medhi et al. (2006), Winschiers-Theophilus (2009), Khaddam and Vanderdonckt (2010), Gorman et al. (2011) and The Unicode Consortium (2012). We have also considered Nasa people-specific research, including interviews with experts on the Nasa culture and a previous work: Checa Hurtado and Ruano Rincón (2006).

The study of the Nasa culture through this cultural model was presented in the second part of the chapter. The application of the model to the Nasa culture resulted in the formulation of a set of design hypotheses and conclusions with regard to the influence of the Nasa culture in the design of computer tools. Such hypotheses were evaluated during the in-field work, process described in the following chapter. The design conclusions and hypotheses found are presented hereafter.

7.3.1 Summary of design hypotheses regarding the Nasa sociocultural context

This section summarizes the hypotheses resulting from the modelization of the Nasa culture. We also describe the reasons why each hypothesis is relevant for the development of computer tools, the considered validation methods and the expected indicators.

Design Hypothesis 1: Nasa school users (teachers and students) agree in the design concept of a cooperative-work capable system based on Nasa social roles and invitations to work.

Why to study it: If the Nasa people place more value on cooperative work over individual work, Nasa pedagogical computer tools should give users the possibility to work collectively, according to their work methods.

How to study it: Interviews with Nasa experts, education authorities and potential users. Evaluation of interface prototypes of a cooperative-work capable tool.

Indicators: Users response to the prototypes.

Related cultural dimensions: **Work organization** from the social organization.

Design Hypothesis 2: Computer interface metaphors based on common objects found in the Nasa context are meaningful for the Nasa users.

Why to study it: The elaboration of computer interface signs based on common and real objects should facilitate the interpretation and use of the computer interface. Hypothesis 3 is a sub-hypothesis of this one.

How to study it: Examination of common objects found in the Nasa environment. Prototype evaluations.

Indicators: According to prototype evaluations, users' understanding of the interface analogies.

Related cultural dimensions: **Common resources** from the environment and Technology.

Design Hypothesis 3: Nasa evaluation users understand the interface metaphor that represents their spatial structuring (collective spaces centered on three-stone hearth).

Why to study it: Similarly to the "parent" hypothesis, interface signs based on common elements would make it easier to unfold the meaning the developer wants to convey through the interface.

How to study it: Evaluation of specific prototypes.

Indicators: According to prototype evaluations, users understand the meaning of the three-stone hearth analogy in the system interface.

Related cultural dimensions: **Common resources** from the environment and Technology.

Design Hypothesis 4: Evaluation users understand the interface structuring according to their left-right World vision. (For example: output information regarding system failures or problems is arranged at the right of the interface; input elements and actions to solve these issues are represented at the left of the interface).

Why to study it: The Nasa World division could determine the elaboration and interpretation of signs composing the interface spatial features.

How to study it: Evaluation of a prototype, with specific features covering failures and maintenance system actions, place at opposite sides of the interface.

Indicators: Results from prototype evaluations: Nasa users understand the use of restoring actions.

Related cultural dimensions: **Vision of the World** from the space structures.

Design Hypothesis 5: Collective evaluation methods are more suitable than individual tests in the Nasa context. The community must be taken into account in the different stages of the tool development.

Why to study it: As found by researchers such as Winschiers-Theophilus (2009), Gorman et al. (2011), and Medhi et al. (2006), in rural and collective-oriented communities, collective evaluations give more fruitful results than individual testing.

How to study it: Comparison between individual versus collective prototype evaluation methods.

Indicators: Results from by collective and individual evaluations.

Related cultural dimensions: **Collectivism versus individualism** and **work organization** from the social organization.

Design Hypothesis 6: Evaluation users agree in the design concept and use of a cooperative work-capable system based on their work organization (*El cabildo* can invite the whole community users to take part in the collective tasks accomplished through the system, while all other *resguardo* inhabitants can only invite a limited group of people).

Why to study it: Confirm the different aspects of the Nasa work organization, and its possible implications in the design of cooperative-work capable computer tools.

How to study it: Interviews with Nasa experts and people from the concerned communities and evaluation of a specific prototype.

Indicators: Degree of acceptance of a cooperative-work capable system based on their social rules compared to the acceptance of individual work systems.

Related cultural dimensions: **Social roles** and **work organization** from the social organization.

Design Hypothesis 7: It is possible to propose new pedagogical games as far as recreational tools are part of educational strategies in Nasa schools.

Why to study it: The possibility of developing pedagogical computer games depends on the use of recreational pedagogical activities in school practices.

How to study it: Research on Nasa pedagogical games. Bibliographical exploration of the school practices and policies. Interviews with education authorities.

Indicators: (1) Existing recreational pedagogical tools or games. (2) The authorization to develop new games, in line with the education authorities' opinion.

Related cultural dimensions: **Education policies** from the social organization.

Chapter 8

Fieldwork in Nasa territory and evaluation prototypes

This chapter describes the results obtained from the fieldwork conducted in Colombia and on the Nasa territory, aimed at evaluating the set of design hypotheses listed in the previous chapter, including the evaluation of the design concept of two different tools: a pedagogical game and a cooperative learning platform.

This fieldwork was carried out during a period between mid-April and August 2010, when we had the opportunity to work with two schools located in different Nasa communities, the *resguardos* of Tumbichucue, municipality of Inzá, and Caldono, municipality of Caldono. These schools were briefly introduced in Section 8.1.

This work was possible thanks to the help of Nasa linguist Abelardo Ramos Pacho, who actively accompanied the author in two working session in both schools. University of el Cauca Anthropologist Esteban Díaz Montenegro and Linguist Tulio Rojas Curieux also played an important role, guiding the process and providing important information about the Nasa culture. Their help has been essential to the development of the thesis.

8.1 The two Nasa schools involved in this thesis

In this section, we introduce the two Nasa schools concerned in this thesis: the IET and the CEFIC. PEBI manages both schools, following similar guidelines. However, the schools present some cultural differences that make them heterogeneous. We spent a total of sixteen days on the Nasa territory divided between the two schools, between mid-April and August 2010.

Besides the general situation of the schools, we will give some details regarding the number of students and teachers, geographical coverage, education focus and computer resources available and their place at the school.

8.1.1 Educational Institute of Tumbichucue

The *resguardo* of Tumbichucue is found in the region known as *Tierradentro*[1], located at the eastern side of the Central mountain range (See Figure 8.1). At the moment when the field work was carried out, a journey from Popayán (the capital and main urban center of the department) to Tumbichucue took, at least, seven hours by bus on a mainly unpaved road.

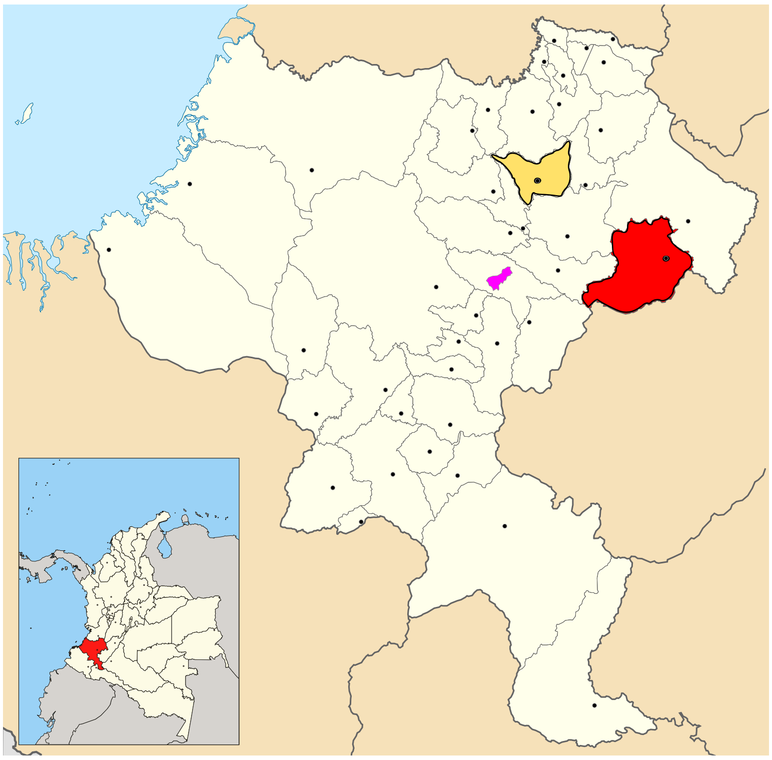


Figure 8.1: Municipalities of Caldono (in yellow), Inzá (in red) and Popayán urban area (purple) in the Cauca department

[1]Tierradentro: "Inner Land", referring to the difficult access conditions.

Students, teachers and Nasa Yuwe situation: The Educational Institute of Tumbichucue was established in 2002. According to Tumbichucue authorities, despite the fact that the school is relatively new, it is a leading center in the region. Almost 100% of native people from Tumbichucue speaks, or at least understands, Nasa Yuwe. Thanks to the vitality of the Nasa language, some parents send their children from relatively distant communities to study in Tumbichucue, the Institute is an appealing center to learn the language.

In 2010, 270 children, aged between 5 and 23 years old, were studying and living in Tumbichucue. The school covers the eleven years of elementary and secondary comprised in the Colombian education system. In 2009, the school granted its first high school degrees to twelve students. The community expects that students that successfully finish their secondary studies become local teachers.

Among the 13 teachers who work in the school, six speak Nasa Yuwe, and are divided in the primary and secondary sections in equal numbers. Five teachers were non-Nasa and they were hired because they have more formal education than local people.

Pedagogical policies: According to the Communal Education Project of Tumbichucue (Institución Educativa Tumbichucue, 2006), a document that describes the school's activities, objectives, organization, etc., the Institute mainly focuses on agricultural training, putting the emphasis on the *tul*, which is the base of the curriculum. The school has two "traditional" *tuls*, one for the primary section and another one for the secondary section.

Computer resources and networking: Regarding computing resources, Tumbichucue has a computer room with eight PCs, interconnected through an ethernet network. However, among them, only three have access to the satellite Internet connection provided by the Colombian State. The school does not have a permanent computing teacher (According to local educators, the position does not appeal to foreigners because of the school's isolated location). At the moment when the field work was carried out, computer classes were taught by a Nasa teacher chosen for this task because she had more experience with computers and had lived in a big city for a period in her life. These classes focused on keyboard and mouse-manipulation exercises. Children have free access to the room (if an adult is present), they can use computers to do research for homework, or for recreational activities. Under normal conditions, children have one hour of computer classes per week in the beginning of the third year.

8.1.2 Centro de formación integral comunitario - CEFIC Hogares - Caldono

CEFIC, Communal Integral Education Center, was one of the first Nasa schools that were established. The CEFIC primary and secondary schools are located in different *resguardos*, respectively Pueblo Nuevo and Caldono, both of which are circumscribed in the same municipality, also called Caldono, in the region known as *Tierrafuera* (Outer Land). Sadly, on account of social problems in Colombia, it was possible to run tests only in the secondary school.

The CEFIC secondary section is located next to a small urban center, where the population is mainly *mestizo* (non-indigenous). Unlike Tumbichucue, Caldono is located on the western side of the mountain range. The region's main towns are more easily accessible from here: it is only at 2 hours and 30 minutes away from Popayán, and 45 minutes away from the Panamerican road, that connects the country's main towns. The interaction with the prevailing industrialized society is stronger and easier than in Tumbichucue.

Students, teachers and Nasa Yuwe situation: In 2010 there were 60 CEFIC students, representing different cultural origins: Nasa, non-indigenous, and 2 children from the Yanaconas native community. Around fifty percent of the Caldono students were Nasa Yuwe speakers.

One the other hand, among the 6 teachers, 2 considered themselves Nasa, and only the Nasa Yuwe teacher was a native speaker of the language.

Pedagogical policies and economic situation: Similar to Tumbichucue, CEFIC also focuses on agricultural activities, including ecological projects. Students and teachers carried out collective funding efforts as well, such as the production of bottled fruit juices to sell in near markets. From time to time, oldest students have to leave the school for short periods of time to work and aid in school funding. CEFIC also plans its calendar so as to make it easier for students to get a temporary job.

Computer resources and networking: The school has a room with 4 PCs, however 2 of them are out-of-service. The school lacks Internet access, but there are a couple of cyber-cafés in the village. Due to equipment limitations, children use the computer only for homework during free hours.

8.2 Validation prototypes

As we have stated before, we chose to validate the acquired knowledge referring to the Nasa culture through two different types of computer tools: computer educational games and a cooperative learning platform. The possibility of developing or adapting these tools to the Nasa context would depend on the validation of two hypotheses: Hypothesis 1 (*Nasa school users (teachers and students) agree in the design concept of a cooperative-work capable system based on Nasa social roles and invitations to work*), and Hypothesis 7 (*Recreational tools are part of educational strategies in Nasa schools*).

Why a computer game? The choice is based on the positive results obtained with the early *çut pwese'je* (Checa Hurtado and Ruano Rincón, 2006). Even if the maize game was considered a successful tool, its design still presents some issues, for example, the abstract idea of disappearing maize is misunderstood. Authors did not explore the possible local games, and çut pwese'jewas based on the exogenous *hangman*. Here, we aim at designing a new game inspired on existing local or traditional Nasa recreational activities.

Why a base interface platform? The purpose of a cooperative learning platform is the authors' initiative to provide the Nasa people with a computer support base for their schools, that fits their pedagogical needs and customs. The interface should provide an alternative to the Desktop metaphor, which, according to observations made by Checa Hurtado and Ruano Rincón (2006), is not understood by Nasa computer users. Through this prototype, we would like to answer the following question: *Is it possible to provide the Nasa students and teachers with a learning platform in agreement with their sociocultural context?*

8.3 A pedagogical game design

In order to design a pedagogical game, the Hypothesis 7 had to be validated first. According to interviews with Nasa Yuwe teachers Rosana Chocué and Bernabé Quisacué, from the *resguardos* López Adentro and Tumbichucue respectively, games, such as *ball and stones*, described below in this chapter, are part of their teaching strategies. We have also found that *CRIC* has developed a number of board games, such as cross and circle, in Nasa Yuwe. Thereby, we can affirm that

Hypothesis validation: Hypothesis 7 is confirmed.

Second, as development strategy, we selected the method proposed by Kam et al. (2009) consisting of three main activities: (1) evaluation of foreign digital games, (2) observation of traditional games, analysed according to Game Patterns (Björk and Holopainen, 2005) and (3) elaboration of computer games according to the analysis of traditional games. We followed a similar approach, the outcome of which is described in this section.

8.3.1 Qualitative evaluation of exogenous educational computer games

The pedagogical activities that were evaluated are part of two educational suites: GCompris[2], and the KDE Education project[3]; a mathematics game called *TuxMath*[4] was also selected.

Exogenous tools selection criteria Those games are available under Free Software licenses, and were selected according to the following criteria: (1) they must be educational tools aimed at children; (2) they should be developed by international teams, in order to include different cultural backgrounds in their designs; and (3) they must be internationalized and localized for Spanish-speaking contexts, at least at a textual translation level.

Brief description of evaluated tools The GCompris, KDE Education project and TuxMath Spanish localized versions included translated text strings. Moreover, GCompris audio files used for interaction with the user were also translated.

We evaluated 3 reading exercises: *Click on a letter*, *Image name* and *Kanagram*; 3 mathematical activities: *Algebra guess-count*, *Balance scales* and *Tux Math*; 2 activities focusing on physical movement: *Water cycle* and *Canal lock*, a musical activity called *Melody*; and the *Tangram* puzzle as an abstract reasoning challenge.

Reading exercises: In *Click on a letter*, after hearing a letter pronounced in Castilian, children have to choose the matching letter displayed in train wagons. The difficulty of differentiating the case letters increases when more wagons are added, until the children reach the locomotive. In the second reading activity, *Image name*, children must *drag-and-drop* 6 image items above their names. Once they are done, they have to click on the *OK* button to verify the answer

[2]GCompris: from the French sentence « j'ai compris » `http://gcompris.net/`

[3]KDE Education project: `http://edu.kde.org/`

[4]TuxMath:`http://tux4kids.alioth.debian.org/tuxmath.php`

(See Figure 8.2.) *Kanagram*, mixes up the letter of a word and children have to find it (Children played the Castilian version). This game gives the possibility of asking for a clue about the word.

Figure 8.2: Reading activities: *Image name* and *Kanagram*

Mathematics exercises: *Algebra guess-count* is based on explicit arithmetic operations. Children have to click on numbers and operators to choose the correct combination that gives a predetermined result. The level increases when numbers and operators are added. In *Balance scales*, children have to *drag-and-drop* masses to balance the scales to the same weight of an object. First, the activity shows the object's weight, so at this point, children have to solve addition problems. Then, the level increases hiding the weight and restricting the number of available masses. The third math exercise was *Tux Math*. Its scenario occurs in outer space, where children have to find the correct result of several arithmetic operations to prevent four igloos from being destroyed by meteors. The latter was the only activity that kept a score record. According to *Tux Math*'s authors, it is "based on the classic arcade game Missile Command."

Physics experiments: *Water cycle* is a tool for learning about the cycle of water and its connection with cities for human needs. Children must click on graphical representations of the sun, clouds, a water pump station, etc. to "activate" them. The goal is to create a whole water cycle in order to supply a town with water service to a town (and so that a penguin to take a shower). *Canal lock*'s challenge is to move a ship through a canal in both directions. Children have to operate (click on) gates and locks and therefore understand the dynamics of water and the way a canal works.

Music and audio exercise: *Melody* is a musical activity for ear and memory training. Children have to listen to sound sequences and reproduce them by clicking on representations of musical instruments. There are three different possible types of instruments to play with. The level increases by making melodies one note longer each time. Children have to click on the *OK* button to start playing.

Abstract reasoning exercises: In this digital version of *Tangram* puzzle, children have to *drag-and-drop* the seven pieces of the puzzle to reproduce the pattern. A right-click on an item makes it turn symmetrically. Dragging around a selected item makes it rotate. There are buttons for all possible operations. There are no difficult levels, just different puzzles.

8.3.2 Exogenous tools evaluation protocol

The first step in the evaluation of these tools was to present them to teachers and authorities in both schools. Afterwards, they evaluation groups were selected. We collectively evaluated the 9 digital pedagogical activities with students and their teachers. In Tumbichucue we worked with two groups of 11 and 20 children, aged between 10 and 13 years old. In Caldono, we worked with three groups of 13, 16 and 19 children, aged between 10 and 18 years old; the third group was composed of non-Nasa Yuwe-speaking children. During the evaluation, we paid attention to: (1) familiarity of interface elements, (2) users' reactions and comments, and (3) computer device manipulation skills.

For each activity, we asked the groups to play freely and encouraged them to say everything they though regarding to the tools, what each element meant, how do they felt, etc. In a similar manner to the tests carried out by Kam et al. (2009) and to the conclusions drawn by Checa Hurtado and Ruano Rincón (2006), we avoided video recording during the evaluations. Nevertheless, we took notes and used an audio recorder, since it is a less intrusive device. We followed the next protocol:

1. The evaluator let the users use the tool freely, without revealing its goal. Guidance was given after a short period of time if the users were unable to unfold the tool's goal.
2. Afterwards, while the children used the tool, the evaluator asked questions concerning the game mechanics and interface:
    - What is the aim of this tool?
    - What is *that element* for?
    - How could I accomplish a *determined action*?

    Users were also asked to accomplish specific actions, such as, going back to the game's main menu, or selecting the next activity, as well as other activity-specific actions.

8.3.3 Major observations

Interface elements familiarity: According to the users' comments, there were unfamiliar elements in activities such as *Water cycle*, *Click on a letter*, *Canal locks*, *Balance scales* and *Image name*. For example, *Water cycle*'s interface includes representations of European-like water tanks, pumps and cleanup stations, and children did not recognize them. *Click on a letter* shows letters in the wagons of a train, a means of transport that does not exist the region. Weight measuring instruments available in Colombia are different from those used in *Balance scales*, however, children easily figured out how to use the activity. Canal is a concept unknown by children of both schools, an explication was needed so they were able to use the *Canal locks* activity.

It is to note that the *Water cycle* interface is decorated with pine trees. During the presentation of the tools to the teachers, one of them said "those trees are not good," due to past problems with the paper industry in the region. This observation was previously made by the Nasa experts when choosing the activities for evaluation. However, the children said they liked those trees. Again in *Water cycle*, it took the participants almost two minutes to understand that they had to click on the sun and other elements to activate them.

Interaction tasks: The most difficult interaction task we observed was *dragging-and-dropping*, used by *Balance scales*, *Image name* and *Tangram*. Tumbichucue children had to try up to four times to successfully move a mass over the scales. In *Tangram*, children also preferred using the buttons rather than dragging around pieces to rotate them. Nevertheless, this problem seems to be less serious in Caldono, where children showed more experience in the use of the mouse.

While in Tumbichucue, the *OK* button in *Melody* and *Image name* did not prompt the user reaction and were misunderstood (the evaluator had to explain its function), children in Caldono knew what the English word *OK* meant and followed the games' dynamic without intervention of the evaluator.

Pedagogical needs: Concerning arithmetic operations in activities, all of the participating children, including Nasa Yuwe-natives, referred to numbers and operations in Castilian. They said they did not know the words for them in the Nasa language. However, the Nasa Yuwe numerals are document in (Ramos Pacho, 2004, p. 24-27).

8.3.4 Observation of local games

We had the opportunity to observe special celebration days in both schools, where students performed presentations, songs, dances, and played local and traditional games. We found differences between the two schools. In Tumbichucue all of the presentations were in Nasa Yuwe and children performed traditional dances, whereas in Caldono, the prevailing language was Castilian and children danced on popular urban music.

As a strategy to understand the children's favorite games, we asked them to draw them freely (As shown in Figure 8.4). This strategy is part of the contextual interviews developed by Druin (1999). Examples of local games we had the chance to observe include:

***Peçxukwe çxuga* (Whipping spinning top)** Called *Cuspe* in other Colombian regions, this is a wooden spinning top of around ten centimeters high. The goal, as for any similar toy, is to make it turn as many times as possible. However, after the initial shove, the player has to strike it continuously with a *fique* fiber whip to keep it spinning. Therefore, this top can spin longer than other top versions. It is worthy to mention that, in Tumbichucue, the record spinning time is 1h40m. This physical and skill-demanding game depends on the player's endurance and ability to strike it correctly.

(The author would like to precise that he participated in the competition in Tumbichucue, and he was unable to strike the spinning top more than four consecutive times before it lost momentum and completely stopped.)

Carretilla We use the Spanish name for *carretilla*, but it seems that there is no precise and particular way to name this toy, people also use *carretilla de palo* or *llanta de palo*. This game uses a wooden stick with two wheels joint together by an axis. One child holds on the stick with his arms and legs, while another one pushes the stick with his shoulder, as shown in Figure 8.3. There is no particular goal. The game ends when the children get bored or tired, and there is no competition either. A teacher said that it was also used as a tool to transport objects.

Zumbambico This is the Castilian name of another popular spinning top, made from the fruit of a tree. The main particularity is that *zumbambico* has a hole in its surface, hence it makes noise (*zumba*) when it turns. The celebration in Tumbichucue also included a *zumbambico* competition. In qualification rounds of four players each, all the players threw the top at the same time. The last top to fall qualified for the next round.

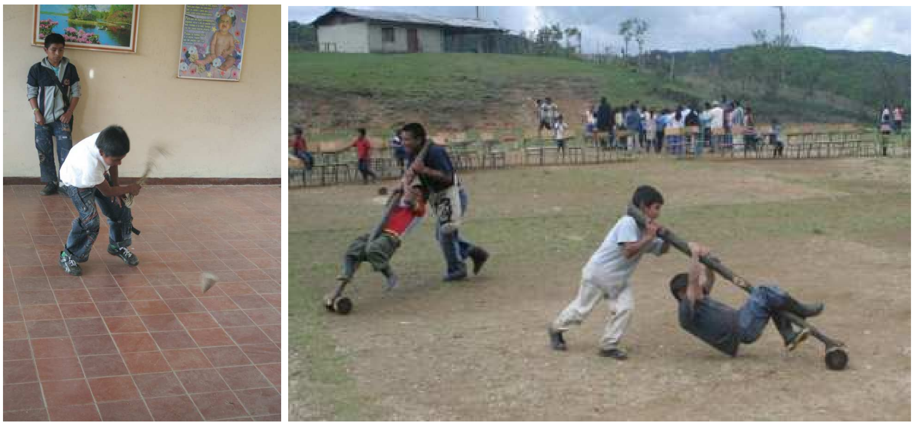


Figure 8.3: Two Tumbichucue local games. Left: a child whipping a spinning top during a competition. Right: students and teacher playing with the *carretillas*

La lleva This is a tag-like game that may have several variations. Children even changed the rules while playing. There are two teams, one chases the other. Once one player is touched, he must go to a specific corner in a limited terrain that serves as "jail". To be freed/released, one of the partners must pass between the prisoner's legs. Players may change teams during the game and new players may join. The game ends by mutual consensus, when they get bored or when everybody is "in jail."

Stones and ball This is a unnamed game consisting of small stones and a plastic ball. It is played by two players sitting on the ground. In turns, each player lets the ball fall and has to pick up as many stones as possible before the ball touches the floor for second time. Rosana Chocué, a Nasa Yuwe teacher in López Adentro[5] takes advantage of this game to encourage her students to practice numerals in Nasa Yuwe: they must count the number of stones they picked up.

The fruit game Played in group, each child takes the name of a fruit. They form a line, where the first child has to hold on to a tree. Two children play the seller and the buyer, the latter has to say the name of each fruit, starting from the last in the line, and pull until it is released. The game ends when the line of fruits is over, or when the buyer is unable to release one of the fruits. We observed children in Tumbichucue playing this game using Castilian words to name the fruit.

[5] *Resguardo* de López Adentro, municipality of Caloto in northern Cauca, located about 30 minutes away from Cali, the third largest Colombian urban center

8.3.5 Local Games Classification with Game Patterns

To classify and characterize the local games, we have examined them according to the nine game pattern categories selected by Kam et al. (2009) from the works of (Björk and Holopainen, 2005). The nine categories that helped us understand the game mechanics are the following:

Players involved, game elements and basic setup: Children never played alone during our observations. Even in the spinning top games, that could potentially be played individually, there were more than two children. Two games involved teams, *la lleva* and *the fruit game*, the others were individual competitions. All of the elements used in the games were simple and rustic, such as stones, wood sticks, plastic balls and tops.

Goals and end conditions: Three games, *carretilla*, *la lleva* and *stones and ball* ended by consensus or when the children got bored. Both spinning top games involved maximizing the top's spinning time. *The fruit game*, *la lleva* and *stones and ball* were also over when there were no more specific elements (such as team members or stones) left.

Rules, modes, actions and events: The few existing rules were basic or flexible. The observations regarding the tag-game were similar to those made by Kam et al. (2009) in India. Some actions involved objects: *throw* tops, balls, stones; *pick up* stones; and *hit* an object with another. *Peçxukwe çxuga* and *stones and ball* may be played in turns. Other games require simultaneous actions, such as *throwing* the *zumbambico*. Others are free of any kind of sequence, such as *carretilla*.

The games were played outdoors, excepting *peçxukwe çxuga*, that could be played indoors as well. It is to note that there was no evidence of board games being played in either school.

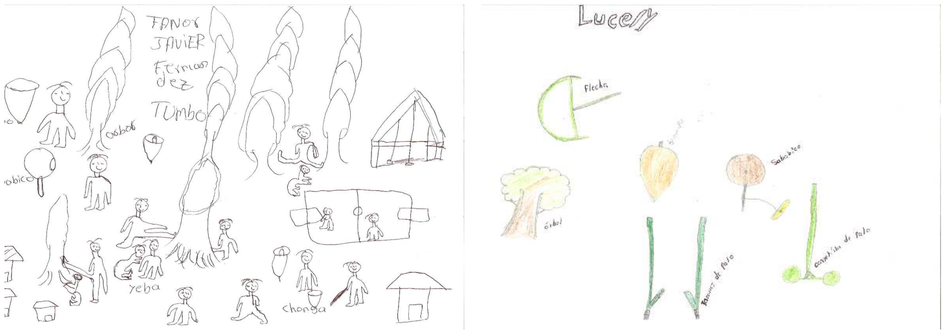


Figure 8.4: Drawings showing Nasa children's favorite games and toys

8.3.6 Requirements and Pedagogical needs

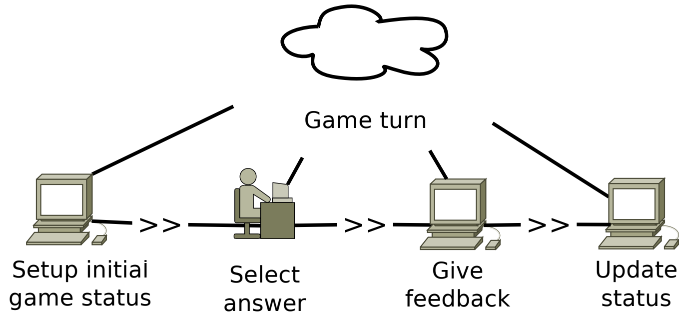
According to the previous characterization of the game mechanics, and the evaluation of the listed hypotheses, we considered the following requirements for the development of a new computer pedagogical game:

1. It should be a *multi-player single device tool:* this is for two main reasons: (1) the Nasa collective orientation and their preference for cooperative work, and (2), the scarce computing resources. A multi-player single device competition game would be possible if the players have to interact with the tool in independent turns. Therefore, a new tool could be based on games such as *peçxukwe çxuga*, *stones and ball* or *carretilla*.

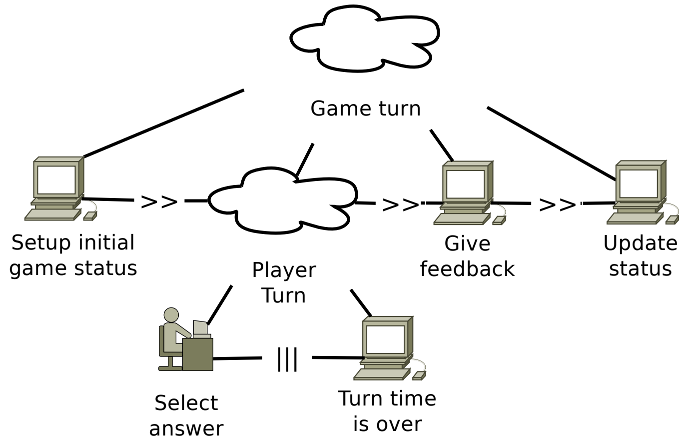
   Moreover, it is possible to identify two possibilities regarding to whether set a time limit to answer a game challenge in each turn or not. This can be described through task modeling, as shown in Figure 8.5.

   It is to note that this cultural characteristics have been considered to define this requirement:

   > **Considered cultural dimensions:**
   > **Environment and technology:** (1) scarce computer resources. (2) Local toys.
   >
   > **Social organization:** value given to cooperative work.



(a) No turn time limit



(b) Time limited turns

Figure 8.5: Task modeling of a game turn. Two design possibilities are described with regard to define whether there should be a time limit for giving an answer at each turn or not.

2. Avoid *dragging-and-dropping:* this was the most difficult interaction task to be accomplished by Tumbichucue students during the evaluation of exogenous computer tools. Also, as stated by Checa Hurtado and Ruano Rincón (2006) and described in Section 7.2.1, a complementary input mechanism is needed in order to write in Nasa Yuwe.

3. *Pedagogical needs:* since Nasa Yuwe numbers and operations are not used frequently, a possible game stimulus would be to perform arithmetic operations in the Nasa language. Concerning the game dynamics, mathematical operations have the advantage of raising an unlimited number of questions, since these can be calculated by the computer during playtime. Written and oral language game challenges would need a database ready to be used by the tool. Current automatic natural language processing technology seems to lack support for Nasa Yuwe.

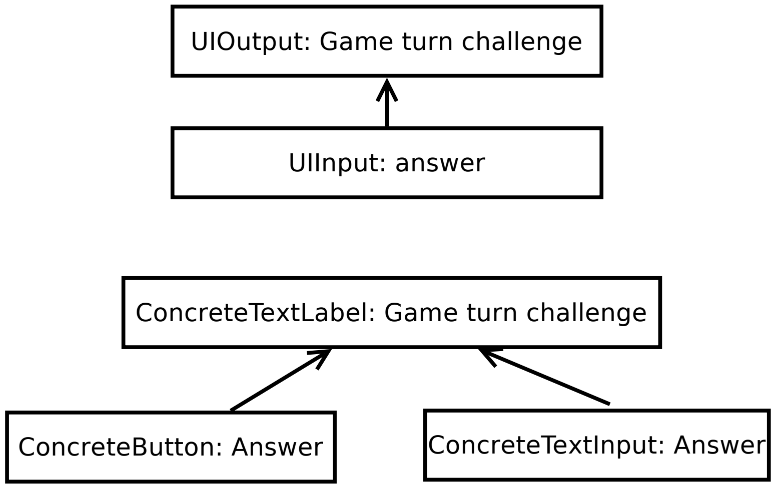


Figure 8.6: Abstract and concrete elements concerning the interaction to give an answer to each game challenge

8.3.7 Initial design and evaluation

Taking these requirements into account, we came up with the idea of a whipping top multi-player competition game. Each player would have to give the right answer to challenges in Nasa Yuwe to make his/her spinning top spin longer than the others'. This idea was introduced to Nasa experts and teachers, to ask their opinion and approval on evaluating it in the concerned Nasa schools.

Game dynamic The default configuration would be a four player competition, with four spinning tops –one for each player– simultaneously represented in the game interface. In turns, the game displays a challenge in Nasa Yuwe that the player must answer.

Wrong answers would make the spinning top lose a part of its energy and wobble. A correct answer given later on would make the spinning top regain motion and re-establish its normal state, as it happens with the *peçxukwe çxuga* when the player accurately strikes the spinning top. However, after a few consecutive wrong answers, the top would fall down and stop and the game would be over for the player. The player whose spinning top is the last to fall wins the game.

We evaluated this game idea mainly in the school of Caldono, in presence of the Nasa Yuwe teacher. In Tumbichucue, we discussed about the game idea with teachers and the school principal. In Caldono, we were able to evaluate the

Figure 8.7: Collective evaluation of the new game mechanics in the school of Caldono. A girl writes the answer to a Nasa Yuwe-related challenge on the blackboard. Her group agreed to the answer.

idea collectively and exhaustively, thanks to the help of Nasa linguist Abelardo Ramos Pacho.

In Caldono we carried out evaluation sessions with three different groups, two groups of bilingual children and one group of Castilian-speaking children, the same group that we evaluated the exogenous activities described in the previous section with. The evaluation groups were divided in 4 or 5 subgroups, each responsible of a spinning top.

We had initially prepared paper prototypes to evaluate the idea, however, given the size of the groups, we decided to use the blackboard as interface prototype and we drew one spinning top for each subgroup. Abelardo Ramos Pacho asked the game questions and challenged the players. The level of questions differed according to the language level of the groups. While bilingual children had to answer complex challenges, the Castilian-speaking group answered vocabulary-related questions.

The game was briefly explained and the children stated that they easily understood the rules. While playing, the children responded actively, were excited, made jokes during the others' turns. But they also seemed to be concentrated and to think carefully about the answers they were going to give, especially the bilingual groups.

Children reactions: Teachers were enthusiastic and proposed ideas for other games. After the evaluation, a child in Tumbichucue spontaneously said he liked the ideas and activities we suggested, and affirmed he was interested in learning how to develop software.

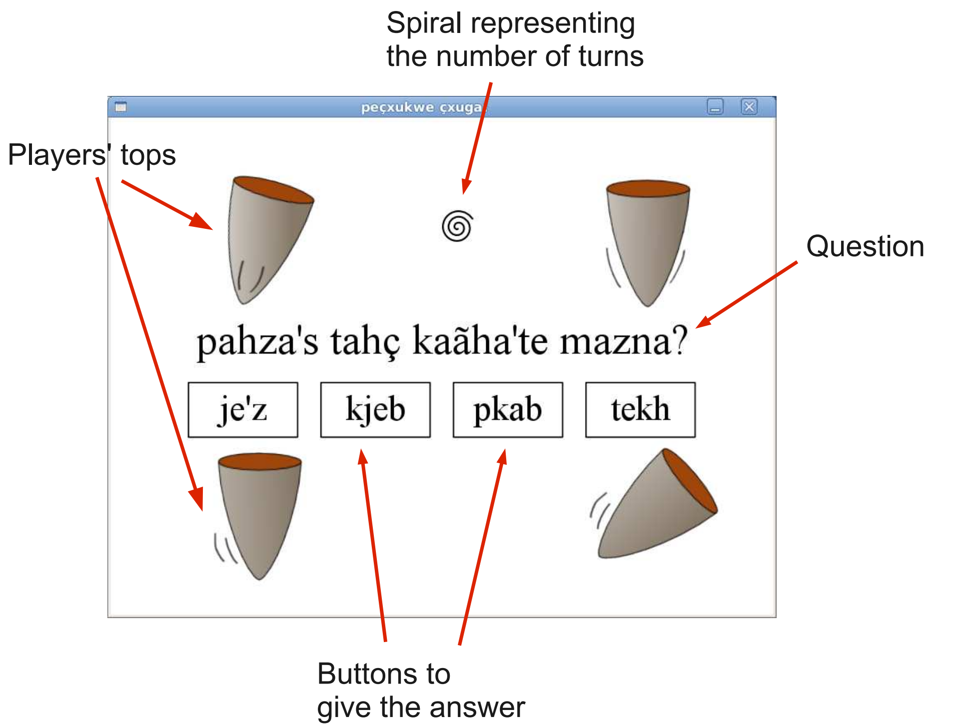


Figure 8.8: Screen-shoot of the *peçxukwe çxuga* computer game, asking how much it is four plus five.

8.4 A cooperative pedagogical computer platform

As we mentioned at the beginning of this chapter, a second design idea was to elaborate, or adapt to the Nasa context, an educational support computer platform. This platform would have to be in agreement with the forms of work organization, the authorities and social roles (replicated in the schools), as well as the available computer resources specific to Nasa sociocultural context. In this section we describe the initial purpose, the manner in which we evaluated the idea with users in concerned schools, the obtained results as well as the decisions taken during fieldwork.

8.4.1 Concerned hypotheses and subsequent requirements

The interface should be based on common elements found in the Nasa context. The evaluation of a computer interface based on common objects would allow the validation of Hypothesis 2. We would pay particular interest to the elaboration of an alternative to the office-desktop metaphor.

This platform's interface prototype should make the validation of Hypothesis 1 possible. If this hypothesis is confirmed, the pedagogical computer platform should enable the users to work in groups. One of the possibilities provided by the system should sharing homework with other users, playing simultaneous multi-player pedagogical games, or sharing tasks provided by the system. This would also be related with Hypothesis 6, *"Evaluation users agree in the design concept and use of a cooperative work-capable system based on their work organization (El cabildo can invite the whole community users to take part in the collective tasks accomplished through the system, while all other resguardo inhabitants can only invite a limited group of people)."*

Concerning Hypothesis 3, the tool must provide two different spaces: an individual and a collective space. In the latter, the user would find, around an analogy to the Nasa hearth, representations of other users connected to the system. In this space, it should be possible to interact with other users and share the different tasks with them.

Internet independent: Given the limited Internet access conditions, it is suitable to develop an Internet-independent platform. However, it would be possible to take advantage of local network capabilities, found in Nasa schools such as Tumbichucue or Pueblo Nuevo[6].

8.4.2 Existing Educational Platforms

Before trying to develop a new platform for the Nasa schools, we examined current learning support platforms in order to consider the adaptation of an existing system to the Nasa sociocultural context. At present day, several learning software support solutions are available. They are also know as learning management systems and some examples are ATutor[7], Moodle[8], ILIAS[9], Fle3[10],

[6]According to observations made on 2006, the school of Pueblo Nuevo counted with 10 interconnected personal computers.

[7]ATutor: `http://sourceforge.net/projects/atutor/`

[8]Moodle `http://moodle.org/`

[9]ILIAS `http://www.ilias.de/`

[10]Fle3 `http://fle3.uiah.fi/`

Sakai[11], among others. All of them share the same general characteristics and are web-based systems, which can be installed on local servers.

From another perspective, there are also operating systems that aim to cover educational needs. Examples of such systems are, among others: KOS (Kid Operating System)[12], Qimo 4 Kids[13], Edubuntu[14], Sugar[15], among others. Excepting Sugar, all of these operating systems are children-aimed adaptations of common Unix-like Desktop environments, with pre-installed educational software.

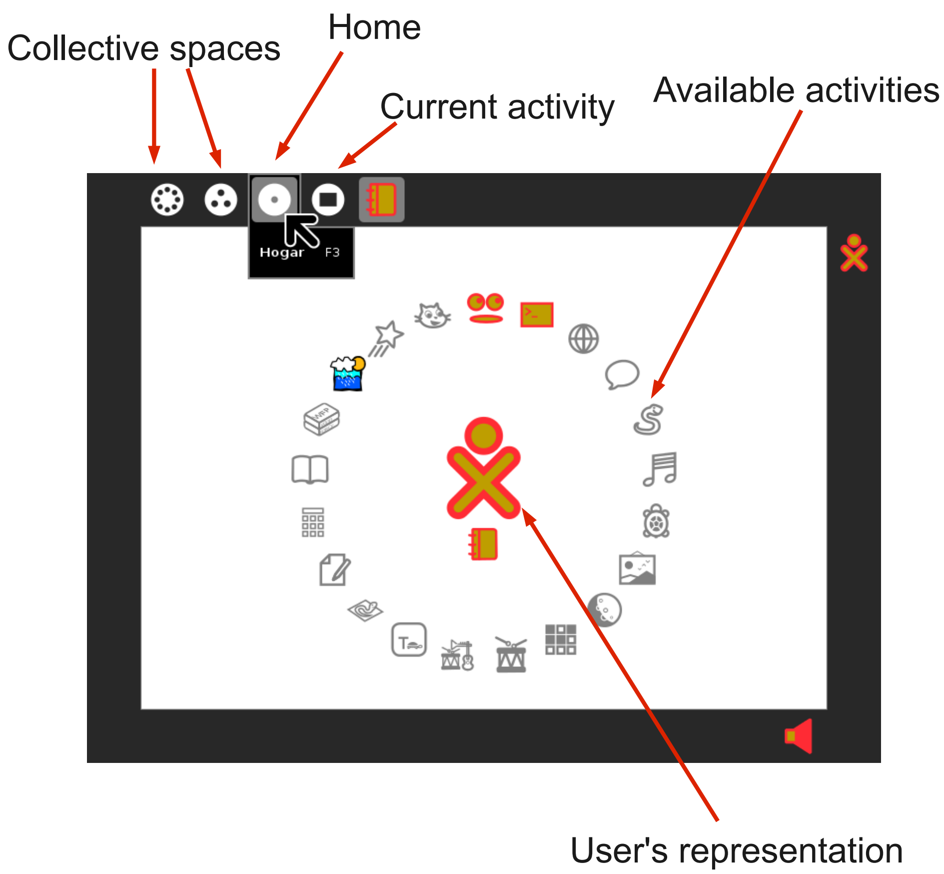


Figure 8.9: User's home in original Sugar

[11]Sakai: http://www.sakaiproject.org/
[12]KOS http://kos.enix.org
[13]Qimo 4 Kids http://www.qimo4kids.com/
[14]Edubuntu http://www.edubuntu.org/
[15]Sugar: A collaborative learning platform. Initially developed for the One Laptop Per Child Project's XO laptops, now maintained by SugarLabs. http://sugarlabs.org

The Sugar cooperative learning platform: Sugar, however, provides the users with an interface alternative to the office-desktop and file-system metaphors. Sugar was originally designed as an operative system for the One Laptop per Child's XO and it was meant to use Mesh wireless networking to support multi-user multi-device cooperative learning systems.

Sugar' user manipulates activities instead of files. There are no folders or any visible file system. The user's previous activities can be review in an analogy to a journal. Among its interface elements, Sugar design includes three different SPACES: the *home* (See Figure 8.9), where the users can find available activities, and two collective spaces: the *group* (See Figure 8.10) and the *neighboorhood*, where the users can see their friends and all of the other users connected to the same network.

Sugar is server-independent. The Mesh wireless network does not require an intermediate device (such as an access point) to connect two or more computers.

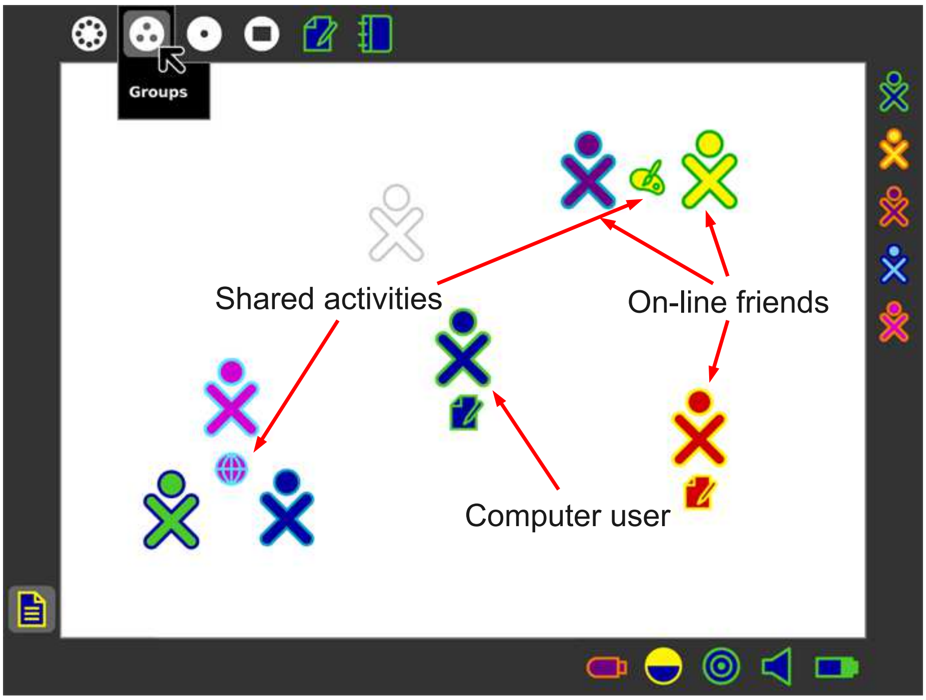


Figure 8.10: User's group space in original Sugar. Based on the image from `http://sugarlabs.org`

Checa Hurtado and Ruano Rincón (2006) made early observations concerning the lack of awareness regarding to the Desktop metaphor by Nasa computer users. According to these observations, we decided that an exhaustive comparison of the use of different educational operating systems by the Nasa would be unnecessary, and we selected Sugar as potential system base for the Nasa educational platform.

8.4.3 Initial design and blackboard-based prototype evaluation

We presented to a group of Tumbichucue school teachers and students the initial design concept based on the requirements described before. This concept was evaluated in Tumbichucue, where we used the blackboard again to illustrate the prototype interface, following a sequence summarized here.

Figure 8.11: Using the blackboard for interface design evaluation. (Left) Discussion regarding the preferred shape at the center of the interface. (Right) Evaluation of the interface structure according to the right-left world division to evaluate Hypothesis 4.

We presented the idea of the possibility of creating a “Nasa computer” for their schools, looking for an alternative to the desktop-metaphor interface. We introduced its main characteristics:

First, the applications available in the interface would be arranged in a rhombus shape. The reference to the *ũhza yafx* seemed to be misunderstood, until it was explicitly described by the evaluator. Thereafter, users suggested arranging the icons in a spiral shape.

Second, to support cooperative work, we described that several users (students) could work on the same task, from different computers. Teachers were very pleased with this idea, and described the different types of work invitations, confirming the Hypothesis 1 and 6.

Hypothesis validation: Hypotheses 1 and 6 are confirmed.

In the cooperative learning platform design, this can be represented by a task model:

Afterwards, we drew a representation of the three-stone hearth on the blackboard, and explained its role in the system as the meeting place for cooperative work.

A teacher suggested redefining this idea, since a space for *mano-cambio* would be needed. The *tulpa* in the interface would be accurate as place to meet other people, but the work is outside. Other teachers seemed to understand his idea and agree with his suggestion. They also claimed that more space would be needed, thus they suggested an additional analogy to the *resguardo*, in order to be able to work with any person in the community.

Hypothesis validation: Hypothesis 3 is confirmed.

Once we agreed on the spaces needed in the interface, we discussed the ways of representing the different functionalities needed in the computer. According to the evaluation group, common computer tool used in the school is the text editor, then we took it as example.

We asked them if they could think of an object that could give access to *cut* and *paste* functions, where it could be possible to find, for example, scissors and glue, to be represented in the computer. The teachers developed the idea of the *jigras* (woolen bags) used to store items, hanging from the house walls on

Figure 8.12: Corn and kitchen tools hanging from the house structures and wall, as a method to store them.

wooden hooks, called *wiika*s. The Nasa use this technique in order to protect food and small objects. The group affirmed “when people do not have tables, they protect items in the house stuff by hanging them on the walls.” Figure 8.12 shows how the Nasa people use to protect and store food and small objects.

Finally, the suggested the design of *wiika*s analogies in the text editor interface as an alternative to the *toolbar*.

To evaluate Hypothesis 4, regarding the right-left interface space division, we drew a warning message related to a computer virus on the right bottom corner of the blackboard, and of the left side, the representation of a tool that would solve the problem. We explained to the users that, with a movement similar to the one performed by the Nasa healer during refreshing rituals (explained in Section 7.2.2), they could eliminate the computer virus.

Unlike the previous ideas, this one was not clear to the users and was misunderstood. Similar results were obtained with a previous in-paper prototype evaluation with Abelardo Ramos. For him, this ideas was inaccurate. Therefore, we can affirm that:

Hypothesis validation: Hypothesis 4 is refuted.

Finally, we presented an early adaptation of Sugar to the users. They could compare the icons’ arrangement in a ring shape (default in Sugar) or in the rhombus shape. The participating group affirmed that they preferred the rhombus shape, and suggested again adding the spiral shape. Figures 8.13 and 8.14 show two screen-shots of this adaptation.

The school principal showed his enthusiasm, and in a further conversation with him, he affirmed that he would like to find fundings to introduce computers with this interface in the school.

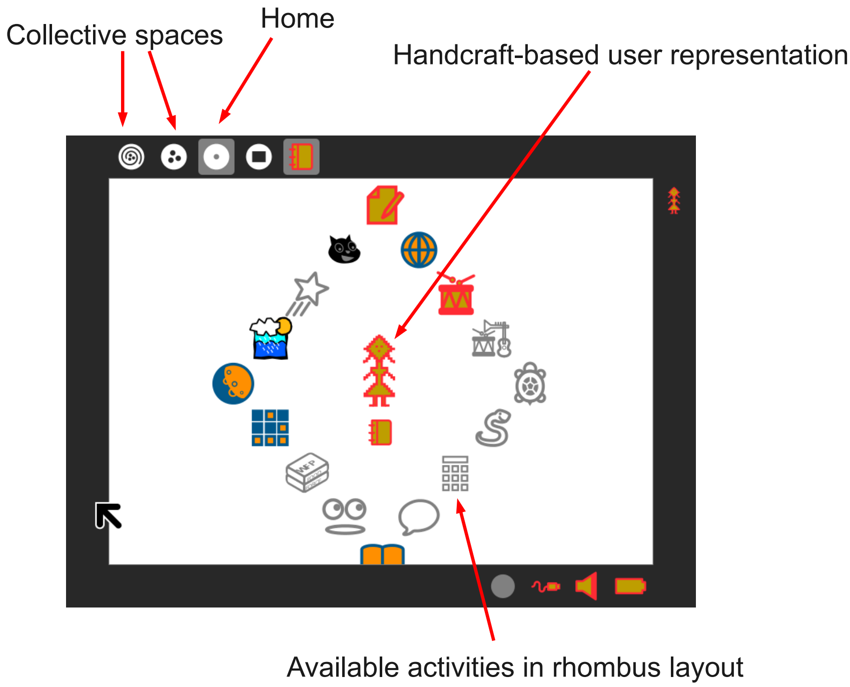


Figure 8.13: User's personal space in the Nasa version of Sugar

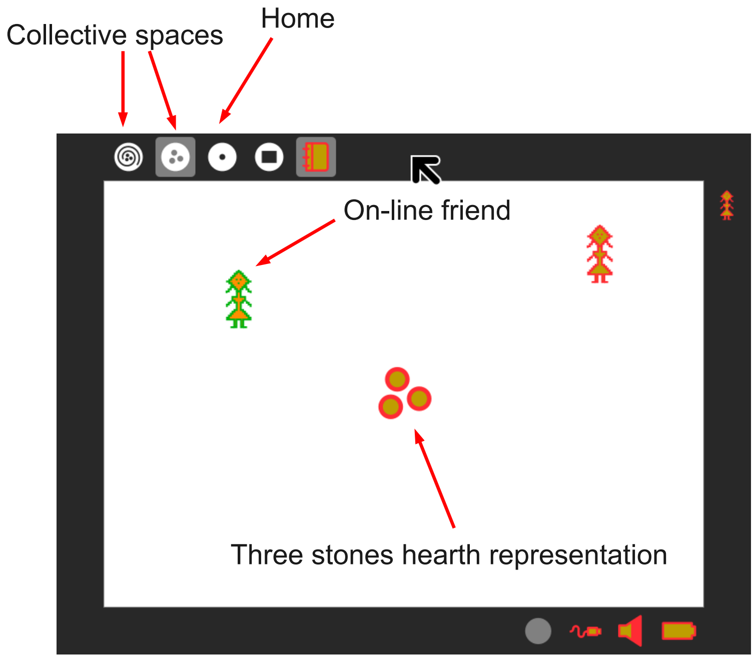


Figure 8.14: User's close friend space in the Nasa version of Sugar

8.5 Conclusions

In this chapter, we have provided a brief description of the main activities accomplished during the in-field work in the Nasa territory, specifically in the schools of Tumbichucue and Caldono *resguardos*. This in-field work aimed at carrying out a qualitative evaluation of the design hypotheses which, as described in Chapter 7, resulted from the Nasa sociocultural context modeling process. Most of these hypotheses were jointly evaluated through the design concepts of two pedagogical tools: a multi-user mathematical game and a cooperative learning platform, both tools aimed at Nasa schools. The outcomes of this evaluation are summarized below. We would like to note that this in-field work faced different unforeseen obstacles that were beyond of our control. Exercising prudence, we had to postpone various trips to the Nasa territory and to look for staying less time than initially planned. Then, our activities, especially those concerning the prototype evaluation, were limited in time. Nevertheless, the main contribution of this thesis is the integration of two models: on the one hand, the sociocultural context characteristics, and on the other hand, specific interactive system designs.

Through this in-field work, we evaluated two design prototypes that made it possible to validate such integration. Let us give some details regarding explicit relations between the two models through the summary of the two prototype evaluations.

8.5.1 *Peçxukwe çxuga*: the whipping spinning top game

Regarding the mathematical computer game, its concept was developed in the Nasa *resguardos* after observing local games and toys. We followed the approach proposed by Kam et al. (2009) that consist of three main activities: (1) evaluation of exogenous computer games, (2) observation of local games and (3) elaboration of computer tools according to the analysis of native games. We evaluated nine exogenous digital games in their Spanish version and observed different recreational activities in both *resguardos*. After a analysis of their game patterns, we decided to proposed a computer version of *peçxukwe çxuga*, a whipping spinning top game.

The education need that this game would help to satisfy to, is to help in learning arithmetics in Nasa Yuwe. This design decision is arisen by the particular weakness in the use of Nase Yuwe in arithmetic operations and numerals, observed in Tumbichucue, where almost all the population is Nasa Yuwe-native-speaking.

We can observe the influence of the Nasa culture through the cultural model dimensions and the game characteristics represented in the design modeling. For example, the **scarce computer resources** (from the *environment and technology* dimension) and the **cooperative work orientation** (from the *social organization*) suggest that a multi-user in turn game is a suitable design option to make the use of a unique computer device possible to several children. This is described through the *task model* shown in Figure 8.5 and by a *design pattern* outlined in Section 9.3.1.

During the evaluation of exogenous tools, we observed differences in computer skills between children from the *resguardos* of Caldono and Tumbichucue. For Tumbichucue children, *dragging-and-dropping* was a difficult interaction technique, and should be avoided in favor of *pointing and clicking*. Therefore, we related **beginner computer skills** (from the *environment and technology* dimension) with determined concrete input interactors, such as *concrete buttons*, that should be preferred over *dragging-and-dropping* interaction techniques.

Theoretical Consideration 8.1. *It is to note that the possibility to describe the decision choice among different design options is the aim of design rationale.*

This recreational computer tool design concept was positively received by Caldono students and Nasa Yuwe teachers. However, linguist Tulio Rojas Curieux subsequently affirmed that Nasa Yuwe lacks standardized numerals and arithmetic operationsPersonal communication. The Nasa people need to agree in how to do mathematics in their language before being able to deploy the *peçxukwe çxuga* computer version. At this moment, its development is on hold.

8.5.2 A Nasa adaptation of the Sugar platform

Concerning the cooperative learning platform, we decided to adapt Sugar, an existing multi-user multi-device framework, since it presented basic characteristics in line with identified system requirements. These requirements include: (1) to allow the cooperative work on pedagogical activities and (2) to structure the interface in different collective and individual spaces. The adaptation we proposed was evaluated with Nasa students and teachers. It also considered some cultural aspects related to specific design solutions, including among others:

- A human user representation designed taking into account the **preferences on graphical representations** (from the *non-verbal signs* dimension), which is related to concrete graphical interaction elements (See Section 9.4.1).
- Nasa **social space structures** (from the *spatial structures* dimension), which influenced the Sugar interface structure design, described by tasks, interaction components and system classes (See Section 9.4.2).
- The **cooperative work orientation** (from the *social organization* dimension) under Nasa specific rules, whose influence on cooperative work system is mainly described through task models (See Section 9.4.3).
- **Cultural meaningful shapes** (from the *non-verbal signs* dimension) to highlight interface elements and their relationship with the Nasa culture, described through concrete layout interface elements (See Section 9.2.2).

These are examples of relationships between the cultural and the interactive system models, that allow us to give the first insights to confirm our research hypothesis, stated in Section 7.1.6. A more detailed description regarding explicit cultural-related design issues-solutions is the aim of the next chapter.

Similarly to *peçxukwe çxuga*, the design concept of this learning platform was successfully perceived by the evaluation groups. However, its deployment into the Nasa schools requires a meaningful effort to train local teachers in the use and appropriation of the tool and its integration in the pedagogical strategies.

8.5.3 Results of the hypotheses evaluation

This section summarizes the results of the evaluation of the design hypotheses during the in-field work.

Design Hypothesis 1: Nasa school users (teachers and students) agree in the design concept of a cooperative-work capable system based on Nasa social roles and invitations to work.

Results: **Confirmed.** The evaluation users positively responded to the prototypes.

Design Hypothesis 2: Computer interface metaphors based on common objects found in the Nasa context are meaningful for the Nasa users.

Results: Besides the validation of the Hypothesis 3, the users also proposed an analogy to other common objects, such as the *wiika* for storing object. This hypothesis is **confirmed**.

Design Hypothesis 3: Nasa evaluation users understand the interface metaphor that represents their spatial structuring (collective spaces centered on three-stone hearth).

Results: **Confirmed**. The users understood the meaning of the three-stone hearth analogy in the system interface. Evalution teachers suggested some changes to improve the analogy.

Design Hypothesis 4: Evaluation users understand the interface structuring according to their left-right World vision. (For example: output information regarding system failures or problems is arranged at the right of the interface; input elements and actions to solve these issues are represented at the left of the interface).

Results: **Refuted**. This design concept was misunderstood by the evaluation users.

Design Hypothesis 5: Collective evaluation methods are more suitable than individual tests in the Nasa context. The community must be taken into account in the different stages of the tool development.

Results: Given time and access limitations experienced during the in-field work, we carried out collective evaluations only. Further work is needed to compare individuals vs collective prototype evaluations. For the moment, we are unable to affirm whether this hypothesis is valid or not.

Design Hypothesis 6: Evaluation users agree in the design concept and use of a cooperative work-capable system based on their work organization (*El cabildo* can invite the whole community users to take part in the collective tasks accomplished through the system, while all other *resguardo* inhabitants can only invite a limited group of people).

Results: **Confirmed.** The users confirmed the work organization in three different types of collective work, which are highly valued, and how they can be applied in the cooperative learning platform.

Design Hypothesis 7: It is possible to propose new pedagogical games as far as recreational tools are part of educational strategies in Nasa schools.

Results: **Confirmed.** This hypothesis was twofold. On one hand, the interviewed teachers include games in learning activities. CRIC and PEBI have developed different board education games. One the other hand, the interviewed teachers and authorities positively answered to the game we proposed.

Chapter 9

Design Patterns to describe Sociocultural Consequences on Computer Tool Design

This chapter focuses on the research question "*How to describe the influence of the users' culture on interactive system design?*" The motivation of this question is to provide ICT experts with reusable design issues-solutions information related to users' sociocultural characteristics. Furthermore, the answer of this question has the underneath goal of explicitly draw the link between two types of models: the cultural model and the interactive systems models.

Our answer is based on two complementary knowledge description methods: Design Patterns and Design Rationale. These methods permit to describe in a semi-formal language the decisions that we considered to solve design issues related to the users' sociocultural characteristics. The issues-solutions are described with the Design Pattern structure and enriched with Design Rationale models, in order to provide additional information about other options, and about the criteria used to evaluate the considered solutions.

In this chapter, the approach is applied to describe the design issues-solutions of three computer tools: (1) *çut pwese'je*, the maize game on Nasa Yuwe character training (See Checa Hurtado and Ruano Rincón (2006), Ruano Rincón et al. (2010)), (2) the *peçxukwe çxuga* and (3) the Nasa adaptation of the Sugar learning framework. The outcome are seven Design Patterns that follow the structure shown in the following section.

9.1 Structure of Design Patterns enhanced with Design Rationale Information

The structure we propose is based on The Gang of Four's Design Patterns on Object-Oriented software (Gamma et al., 1995), Paternò's User-Interface Design Patterns (Paternò, 1999) and the Question-Options-Criteria (QOC) Design Rationale Model, initially conceived by MacLean et al. (1996, p. 53). Moreover, the structure includes the tool description through models of different abstraction levels. The cultural characteristics that arose the issue and that influence the solution are also described. The resulting structure is composed of following elements:

Name: A meaningful pattern identification name.

Intent: Short description of the particular design issue that the pattern aims to solve.

Cultural categories: The cultural model categories related to the pattern.

Motivation: A scenario describing the issue and how the considered possible options address it.

Options: Different design solutions considered to solve the issue.

Criteria: The criteria taken into account in the evaluation of the possible options for solving the design issue.

Evaluation: A comparison table summarizing the evaluation of each solution considering the different criteria. This table has the format shown in Figure 6.3.

Applicability: Situations when the design solution could be applied.

Structure: Graphical representations of tasks, concrete user interfaces, and classes composing the chosen solution.

Participants: A more detailed description of the elements composing the system.

Consequences: What are the outcomes of using the pattern? How can the design solution achieve its objective?

Known Uses: Examples of the use of the pattern in real systems.

Related Patterns: Other design patterns related to this issue-solution, and a description of the differences between them.

This section summarizes part of the design issues of the three computer tools listed above. These issues arise from Nasa cultural particularities and from their differences with developers’ cultural background. The issues and their solutions will be described as Design Patterns in the following sections. The design patterns we propose are: (1) Text Input, (2) Culture-highlighting layouts, (3) Multi-user tool for in turns use, (4) Human or other living being graphical representation, (5) Social interaction spaces, (6) User’s authority role and (7) Task sharing.

9.2 *Çut pwese’je* (The maize game)

Çut pwese’je is the Nasa Yuwe alphabet training tool designed with a hangman-like dynamic. As previously described, the player must guess a hidden word in order to prevent the disappearance of a maize field. Part of the design issues found during the game development process are related to: (1) the input of text in Nasa Yuwe and (2) the arrangement of graphical elements according to culturally meaningful shapes.

9.2.1 Text input

We have found a text input issue related to three cultural dimensions: (1) ***Language***: the Nasa Yuwe writing system script composition. (2) ***Environment and Technology***: the text input media available in the users’ context. (3) ***Social Organization***: pedagogical literacy needs. Considering these dimensions, we can identify the first design issue:

Design Issue 1. *How to enable the user to input Nasa Yuwe graphemes and distinguish the phonetic units?*

We can thus consider three different options to input text into an interactive system: (1) The current physical keyboard. (2) An auxiliary graphical tool composed of five input options: the four basic nasal vowels and the letter ç. (3) An on-screen keyboard with an input option for every Nasa Yuwe grapheme.

The solution proposed by Checa Hurtado and Ruano Rincón (2006), consisting in a complete on-screen keyboard, composes the *Text Input* Pattern, described thereafter.

Design Pattern: Text Input

Intent: Provides a graphical alternative to allow users to input any Nasa Yuwe grapheme when they need to enter data in text form. This is an alternative to Latin-American Spanish keyboards, which lack the characters for nasal vowels and the letter ç.

Cultural categories: This pattern is related to consequences from four Nasa cultural characteristics.

- ***Language:*** *Script and Alphabet composition*. The Nasa Yuwe alphabet is based on Latin characters. Besides 23 “basic” characters (Latin characters without diacritical marks), it includes the tilde diacritic which represents nasalisation in vowels, and the letter ç.
- ***Environment and technology:*** *Text input media*. Latin-American Spanish keyboards are the most common in the Nasa environment.
- ***Social organization:*** *Pedagogical needs*. Digraphs and trigraphs have to be identified as phonetic units.
- ***Non-verbal signs:*** *Numerical sequences*. The Nasa Yuwe literacy process is based on the 4-2-4-1-4 numerical sequence, based on a Nasa world vision and which establishes the consonant learning order, described in Section 7.2.1.

Motivation: The need of a text input interface for Nasa Yuwe has two main reasons:

1. Common keyboards available in the Nasa territory lack input options for nasal vowels, represented with the tilde diacritic (˜), and the letter ç.
2. There are 38 digraphs or trigraphs[1] (e.g. ĩh, ee, ũu, çx, pxh) among the 69 Nasa Yuwe graphemes. For pedagogical reasons, it is important that those who study the alphabet know that they represent phonetic units.

[1]Considering glottalized vowels, such as i’, e’, ã’, ũ’, as single graphs.

Options:

1. Latin American Spanish hardware keyboard
2. Complementary graphical tool with missing graphemes

ĩ	ẽ	ã	ũ	ç

3. On-screen full keyboard

Criteria:

1. Alphabet coverage
2. Identification of digraphs and trigraphs as phonetic units
3. Interface space economy
4. Culturally meaningful
5. Consideration of alphabet learning order

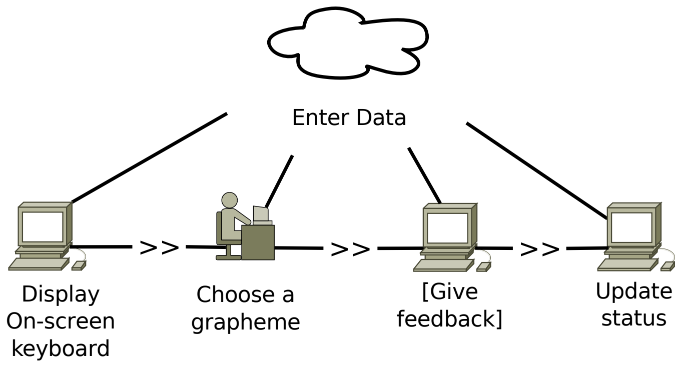
Evaluation:

	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Criterion 5
Option 1	-	-	+	-	-
Option 2	+	-	-	-	-
Option 3	+	+	-	+	+

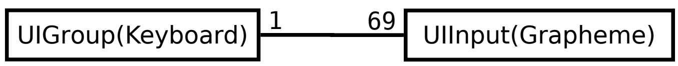
Applicability: Systems with keyboard or any other input device with incomplete Nasa Yuwe writing support.

Structure:

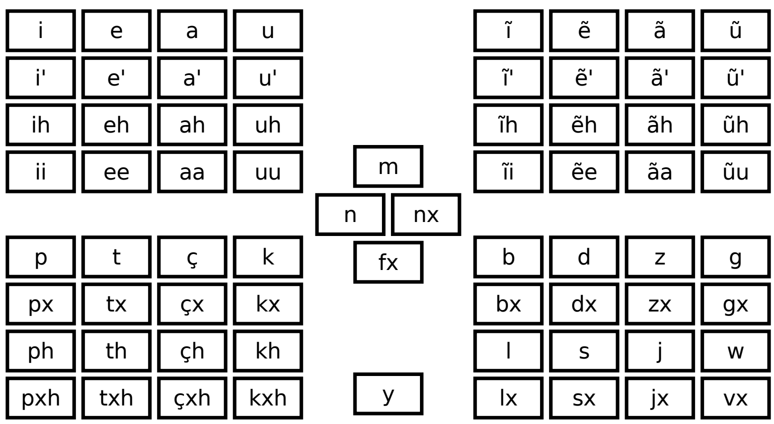
- Tasks:



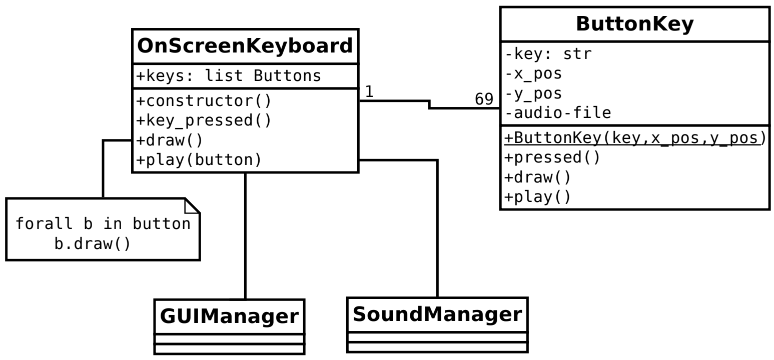
- Abstract Interactors:



- Concrete Presentation Layout:



- Classes:



Participants:

- Tasks:
  - **Choose a grapheme**: The user selects a grapheme from the on-screen keyboard.
  - **Give feedback**: The computer reproduces the sound corresponding to the grapheme selected by the user (Optional task).
- Classes:
  - **ButtonKey**: Defines a Button to be used as key to select a grapheme.
  - **OnScreenKeyboard**: Comprises all the keys, creates all the buttons and assigns their relative position in the graphical interface.
  - **GUIManager**: Graphical User Interface Manager, defined by the graphical library used by the tool. It should be able to trigger and handle interface events.
  - **SoundManager**: An optional class responsible for giving the user auditive feedback after a key-button is clicked on. For literacy training, the character's phoneme should be reproduced.

Consequences: This patterns creates an on-screen keyboard composed of buttons for every single Nasa Yuwe grapheme. A disadvantage of this solution is it requires a considerable amount of graphical space in the interface.

Known Uses: (1) Keyboard used in *Comunidad virtual de apoyo a los procesos de etnoeducación nasa* `http://www.ewa.edu.co`. (2) Çut pwese'je (the maize game)

Related Patterns: None

9.2.2 Meaningful graphical arrangement of a group of elements

The game's main stimulus is a maize field, represented in the interface through sixteen maize images. One of the design's requirements was to explicitly show the Nasa relationship with the game. To satisfy this requirement, the maize field was graphically configured according to culture meaningful shapes.

This design issue and its solution have a strong cultural dimension: ***Non-verbal Signs***: meaningful shapes

Design Issue 2. *How to graphically arrange a group of glyphs in order to highlight the relationship between the computer tool and the Nasa culture?*

Two layouts were considered in the design of the maize images: (1) two rows of eight glyphs each and (2) a rhombus layout.

The solution to this design issue is described in the *Meaningful Layouts* Pattern.

Design Pattern: Culture-highlighting layouts

Intent: Graphically arrange a group of glyphs in order to highlight the tool's relationship between the tool and the Nasa culture.

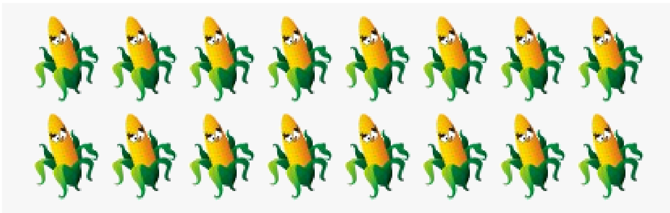
Cultural categories: ***Non-verbal signs:*** *Meaningful shapes and Cultural symbols*. There are two meaningful shapes among the different Nasa aesthetic expressions: the rhombus and the spiral.

Motivation: In different design evaluation sessions, users (students and teachers) made positive appreciations of the interfaces that included shapes meaningful to Nasa culture, such as the rhombus (the *ũhza yafx* symbol) and the spiral. These two shapes can be used, for example, to graphically arrange groups of elements of the same type.

Consider the maize game design and the non-functional requirement of explicitly show the relationship with the Nasa culture: to satisfy this requirement, the sixteen-maize field were graphically configured and two different layouts were evaluated.

Options:

1. A rectangular layout composed of two rows of 8 glyphs each.



2. A rhombus-layout, similar to the Figure 9.2 (a).

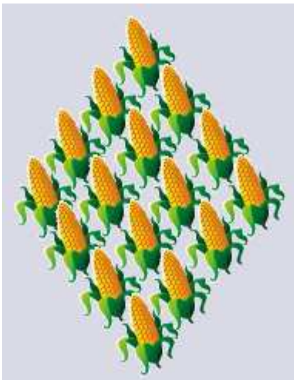


Figure 9.1: Maize graphically distributed in a rhombus layout.

Criteria:

1. Culturally meaningful
2. Interface space economy

Evaluation:

	Criterion 1	Criterion 2
Solution 1	-	+
Solution 2	+	-

Applicability: Graphical interfaces including a group of glyphs of the same type.

Structure:

- Concrete Presentation Layout:

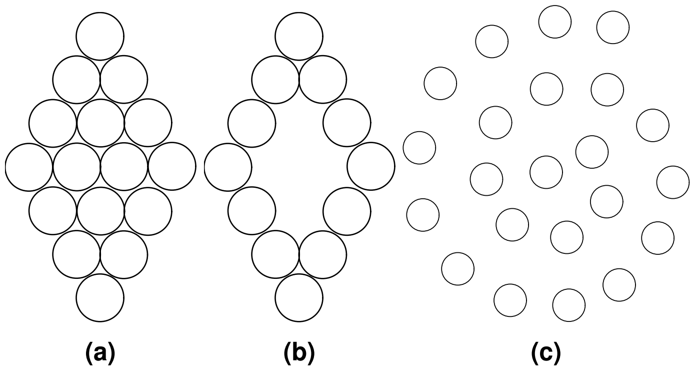
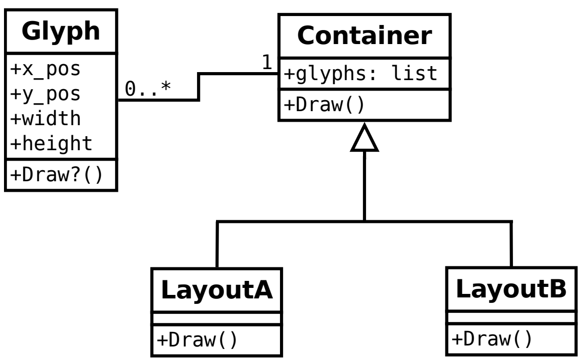


Figure 9.2: Layout possibilities representing two rhombus shapes and a spiral.

- Classes:



Participants:

- Classes:
  - **Glyph**: Graphical element to be arranged in the Container.
  - **Container**: Class that controls the glyphs, their position, and passes the layout responsibility to Layouts classes. It enables the user to choose among different layout possibilites.
  - **LayoutA** and **LayoutB**: Each class implements a different concrete layout.

Consequences: The application of this pattern does not have known drawbacks.

Known Uses: The Nasa adaptation of Sugar: Activities (applications) icons are graphically arranged in a layout selected by the users, including the rhombus and the spiral as possibilities. Çut pwese'je: graphically arranges the sixteen maize field in a rhombus shape.

Related Patterns: None

The following code implements the rhombus layout in the Nasa adaptation of Sugar. This code is included in the favoriteslayout.py file.

```
Class RhombusLayout(FavoritesLayout):
    ...

    def _calculate_position(self, radius, icon_size, index,
                            children_count, sin=None, cos=None):

        def cos_d(d):
            while d < 0:
                d += 360
            if d <= 180:
                return (90 - d)/90
            # mirror around 180
            return cos_d(360 - d)

        cos = lambda r: cos_d(math.degrees(r))
        sin = lambda r: 1.2 * cos_d(math.degrees(r) - 90)
```

9.3 *Peçxukwe çxuga* (The whipping spinning top)

As previously described, the player's goal in this pedagogical game is to make a spinning top turn as much as possible. We describe here a design issue related to the scarce computer resources.

9.3.1 Multi-user devices (Or making use of scarce computer resources):

The main design issue described here is related to the scarce computer resources available in the Nasa context, categorized in one cultural dimension: ***Environment and Technology***: Nasa computer resources are scarce. The ratio of students to computer is around 30 to 1. Therefore, we can define the third design issue:

Design Issue 3. *How to make use of the scarce computer resources available in the Nasa environment?*

As a design solution, we decided to elaborate a multi-user pedagogical game, in which several players could play in competition. This design issue-solution constructs the *Simultaneous Multi-User Tool* Pattern, shown here below.

Design Pattern: Multi-user tool for in turns use

Intent: Allow several users to interact in turns with the computer tool, in order to maximize the use of the scarce computer resources available in the Nasa environment.

Cultural categories:

- ***Environment and Technology:*** *Computer resources*. The ratio of students to computers in the Nasa schools involved in our evaluation was around 30 to 1 in 2010. Computer resources are scarce, compared to countries such as the United States, where the ratio of public school students to instructional computers with Internet access was 3.8 in 2005 (Wells and Lewis, 2006, p. 24).

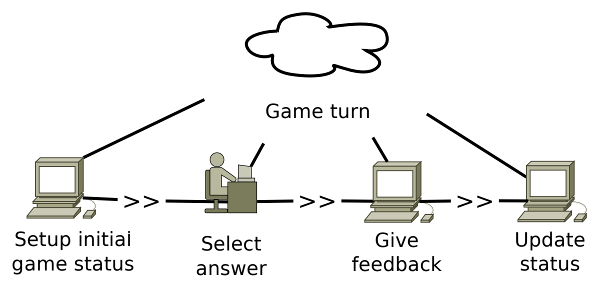
- ***Social Organization:*** *Time value*. According to interviews with Tulio Rojas Curieux, Nasa people place a relatively low value on time.

Motivation: Given the limited number of computers per students in the Nasa schools, these should be provided with tools that can be used simultaneously by several children.

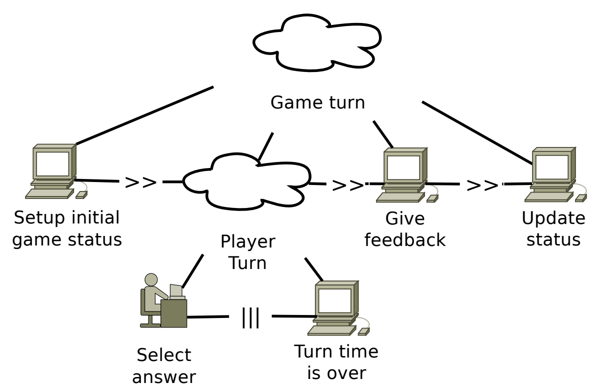
A design requirement for the whipping top computer version was to create a multi-user competition game. Several players compete to make their spinning top turn longer than the others.

Options: A game design question was whether it was suitable to set a time limit for each turn or not. We had two design options:

1. No turn time limit



2. Time limited turns



Criteria:

1. Consistency with the value placed on time
2. Consistency with the actual whipping top

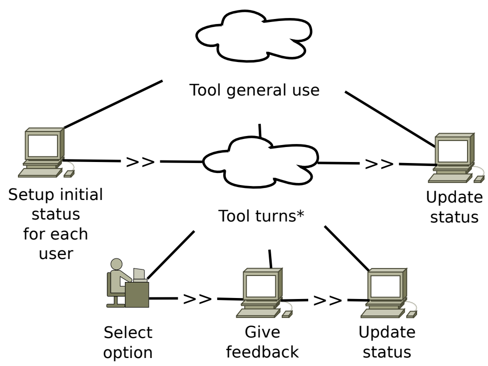
Evaluation:

	Criterion 1	Criterion 2
Solution 1	+	-
Solution 2	-	+

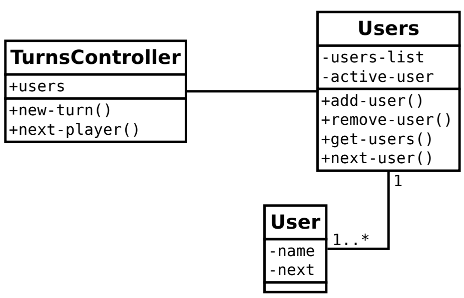
Applicability: Competition games.

Structure:

- Tasks:



- Classes:



Participants:

- Classes:
  - **TurnsController**: Manages the turns
  - **Users**: Manages the set of users
  - **User**: Structures the user's basic information

Consequences: The application of this pattern does not have known drawbacks.

Known Uses: *Peçxukwe çxuga*: the whipping top is a multi-user competition game. Up to four players can compete at the same time.

Related Patterns: None

9.4 Nasa adaptation of the Sugar cooperative learning platform

The third considered tool is the adaptation of the Sugar platform to the Nasa culture. Sugar is a cooperative learning environment, allowing to share learning activities among users of different computers. Several design issues and their solutions have been considered in this adaptation: (1) How to graphically represent the system user? (2) How to represent the social interaction levels? (3) How to organize the cooperative work according to Nasa social rules? (4) How to arrange graphical representations of available tools? The first three issues-solutions are drawn hereafter. The last one will reuse the design solution described by the *Culture-highlighting layouts* Pattern (See Section 9.2.2).

9.4.1 User graphical representation

Previous observations have shown that Nasa people prefer realistic or familiar images rather than abstract or complex illustrations. As mentioned in Section 7.2.5, this was observed in the case of the maize images in *çut pwese'je*. This issue is characterized by the Nonverbal signs cultural dimension: ***Nonverbal Signs***: Preferences on graphical representations.

Design Issue 4. *How to graphically represent the user?*

This concrete graphical representation is described in the *Living Being Graphical Representation* Pattern.

Design Pattern: The graphical representation of humans or other living beings

Intent: Graphical representation of a human or other living beings. Aims to provide concrete graphical representations consistent with the Nasa aesthetic preferences.

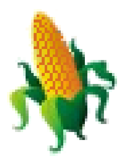
Cultural categories: ***Non-verbal signs:*** *Preferences in respect of graphical representations*. It is suitable to graphically represent the user or any other living being according to the Nasa cultural products.

Motivation: According to previous observations made by Checa Hurtado and Ruano Rincón (2006), Nasa people tend to be uncomfortable with non-realistic or abstract representations. A maize cob had to be represented in the maize game interface. Two options, shown in Figure **??**, were evaluated.

Options: Two options to graphically represent a maize plant

1. Maize with eyes and a nose

2. More realistic maize cob



However, there are human representations in the Nasa cultural products. For example, Figure 9.3 shows a couple of friends on a woven fabric ribbon made by Nasa women. This representation can inspire graphical icons in the computer interface.

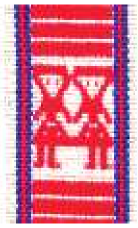


Figure 9.3: A *chumbe* (woven fabric ribbon) section showing a couple of friends. Image taken from Lasso Sambony and Calambás Sánchez (2005)

Criteria: the evaluation of the graphical representation of two maize cobs.

1. Consistency with the Nasa graphical representation preferences.

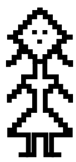
Evaluation:

	Criterion 1
Solution 1	-
Solution 2	+

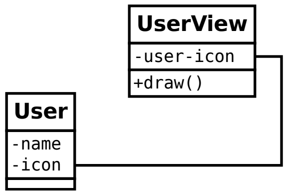
Applicability: Interface elements requiring a graphical representation of humans or other living beings.

Structure:

- Concrete Graphical Representations:



- Classes:



Participants:

- Interface Elements:
  - **UIElementImage**: Human Representation
- Classes:
  - **User**: Models the User
  - **UserView**: Responsible for drawing the User icon.

Consequences: The use of abstract or non-realistic images might be awkward in the Nasa context. There are not known drawbacks of the application of this pattern.

Known Uses: Graphical human agent representation

Related Patterns:

- *User Authority Role* Pattern, Section 9.4.3.

9.4.2 Social interaction spaces

The design of a cooperative work-capable system required to take into consideration a possible representation of the different Nasa social interaction spaces. This issue refers to the elaboration of an analogy to Nasa common spatial structures and its solution is related to the cultural dimensions: (1) ***Space***: Spatial structures: The Nasa collective spaces begin with the hearth, expand to the *resguardo* and larger communities. (2) ***Social Organization***: social interaction levels (3) ***Nonverbal Signs***: Shapes: the spiral is related to territorial extension. A spiral centered around a three stone-hearth may represent the different social interaction levels.

Design Issue 5. *How to represent the Nasa social interaction spaces in the system interface?*

The analogy we proposed to resolve this issue permits to elaborate the *Social interaction spaces/levels* Pattern.

Design Pattern: Social interaction spaces

Intent: Creates an analogy to the Nasa social interaction levels in the system interface. Defines the structure and graphical representation of different levels of user communities in a cooperative work-capable system, wherein human agents can interact with each other through a computer network.

Cultural categories:

- ***Space*** and ***Social Organization***: *Social interaction spaces*. Two meaningful collective spaces related to different social interaction levels can be identified: the first one is the *tulpa* (a three-stone hearth), where family and close friends meet, and the second one is the *resguardo*, the main communal territorial unit.
- ***Non-verbal signs:*** *Shapes and figures*. (1) A spiral centered in the three-stone hearth represents the different social interaction spaces. (2) The human representation is needed to create an analogy of the user and his social groups around the *tulpa* or inside the *resguardo* interface representations.

Motivation: Consider a multi-terminal cooperative work-capable system. The interaction communities can be constructed according to actual social interaction levels delimited by spatial “boundaries”.

According to Nasa teacher and leader Mincho Ramos (as cited by Rappaport (2005)), the Nasa social interaction levels start at the familiar space around the three-stones hearth, and they expand to larger spaces: the house garden, the communal farms, the *resguardo*, the municipality and other Colombian territorial administrative divisions. Mincho Ramos affirms that these spaces can be represented by a spiral centered around the hearth, which expands as it reaches larger spaces.

We can create a graphical analogy to these spatial social structures, taking into account the User graphical representation.

According to the users who evaluated this design idea, two collective spaces would be needed: the *tulpa* and the *resguardo*.

Options:

1. Two spaces: one individual and one collective. This latter referring to the *tulpa*.
2. Three spaces: one individual and two collective: the *tulpa* and the *resguardo*.

Criteria:

1. Consistency with Nasa social interaction levels.
2. Consistency with collective work organization.

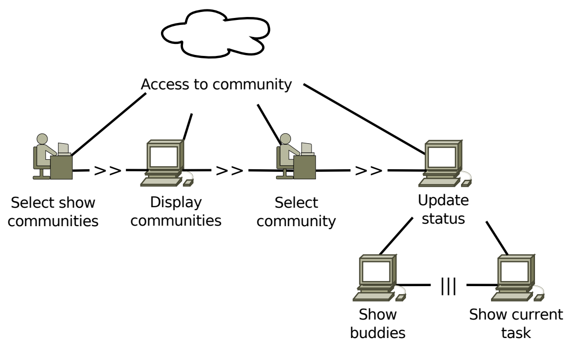
Evaluation:

	Criterion 1	Criterion 2
Solution 1	-	-
Solution 2	+	+

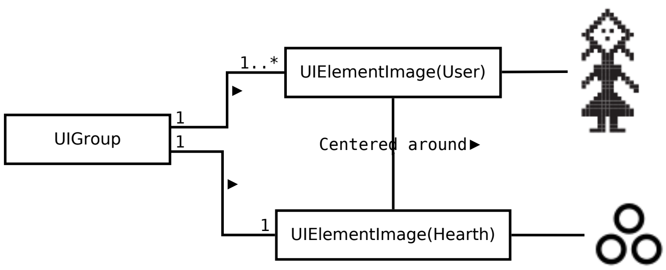
Applicability: Multi-terminal cooperative work-capable systems.

Structure: Here, we show the basic models concerning the Social Interaction Spaces. We will give more details in the Appendices.

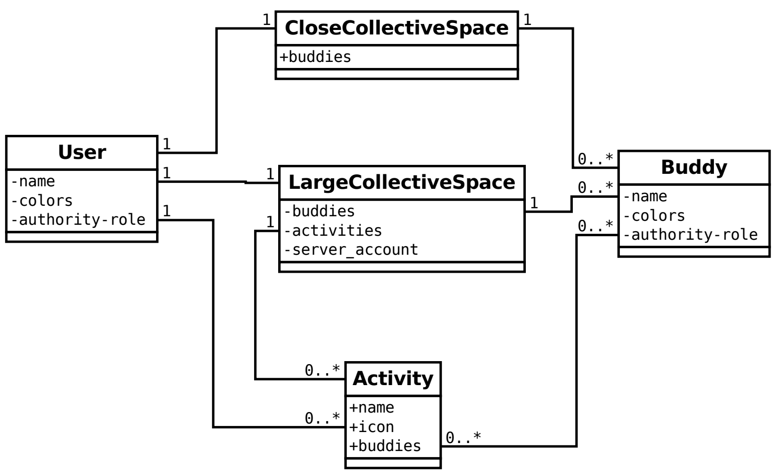
- Tasks:



- Abstract Interactors and Concrete Images:



- Classes:



Participants:

- Concrete Graphical Interactors:
  - UIElementImage: **HumanRepresentation**: graphical user representation.
  - UIElementImage: **FamiliarSpace**: three circles as graphical analogy to the three-stones hearth.
  - UIGroup: **SocialSpace**: Groups the system users and their representations around the three-stones hearth.
- Classes:
  - **User**: User Model Class
  - **CloseCollectiveSpace**: Models the close relationships social space.
  - **LargeCollectiveSpace**: Models the collective territorial unit.
  - **Buddy**: Class representing other computer users.
  - **Activity**: Software tools available in the system.

Consequences: The application of this pattern does not have known drawbacks.

Known Uses: The Nasa Sugar adaptation collective spaces are designed according to this pattern.

Related Patterns:

- *Human Representation*, Subsection 9.4.1,
- *Share Tasks*, Subsection 9.4.3.
- *User Social Role*, Subsection 9.4.3

9.4.3 Activities sharing

We use the Sugar characteristics allowing to share activities with other users through a computer network. The Nasa people place a high value on cooperative work, which is considered as a mean of reaffirming being part of the community. This issue refers to the cooperative work organization in a multi-device platform, characterized in the cultural model through the following dimension: ***Social organization***: Work organization: collective work value.

Design Issue 6. *How to organize cooperative work according to Nasa social rules?*

We also found that the Nasa work organization raises another design issue:

Design Issue 7. *Taking into account the users' social roles and representing authority?*

This Design Issue 6 is developed in the *Task sharing* Pattern, while the Design Issue 7 composes the *User's Social Role* Pattern. Both patterns are described hereafter.

Design Pattern: Task Sharing Pattern

Intent: Organize a cooperative work environment according to the Nasa social work rules.

Cultural categories: ***Social Organization:*** *Work organization*. The Nasa place a high value on cooperative work. The Nasa work organization is based on three different types of collective work, which depend on the purpose of the task and on the social role of the people who invite to work.

Motivation: Consider a multi-terminal cooperative work-capable system. User task sharing should be based on the social conventions related to work. The Nasa people values collective work, whose organization is based on invitations. Those invitations can be divided in three types: *mano-cambio* (hand-exchange), *mingas* (communal work parties) and *el cabildo invita* (invitations issued by the council). Whereas the first two may reflect a personal or familiar interest, the *cabildo* invitations address communal goals.

As their name suggests, *cabildo invitations* are issued by members of the communal council. The type of invitation that the user may send depends on his/her social role: all users can invite others to join in a private-interest task, while *cabildo* members can also invite the whole community (*resguardo*) to participate in collective endeavors.

This implies taking into account the possible user's role, whether he/she is a *cabildante* or not.

Options: A single option was considered in this design solution.

Criteria:

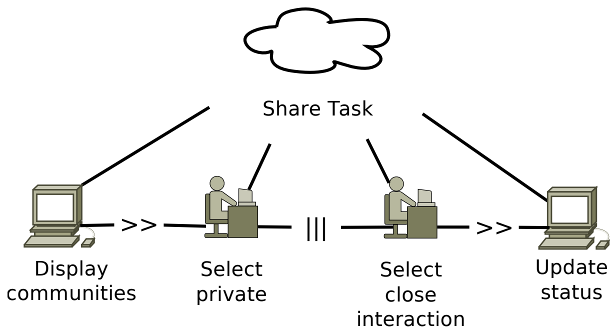
1. Consistency with cooperative work rules.

Evaluation: This pattern does not include an evaluation since only one option has been considered.

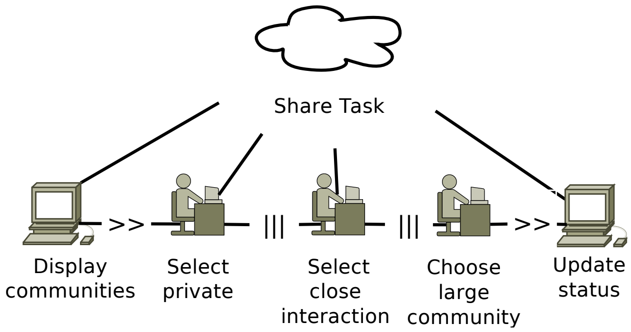
Applicability: Multi-user, multi-device cooperative work capable systems.

Structure:

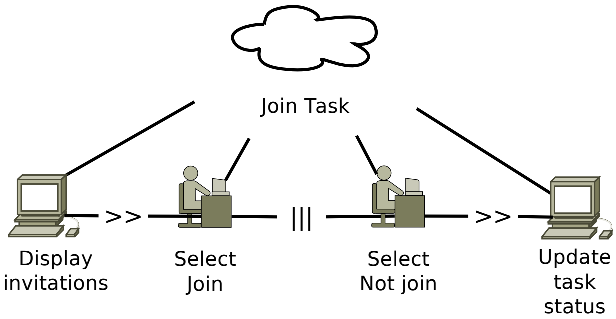
- Tasks:
  - Task sharing possibilities for a non-*cabildante* user:



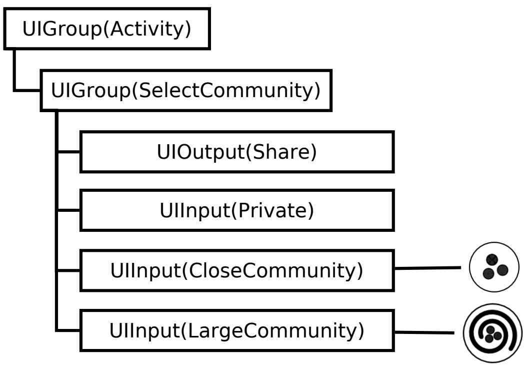
- Task sharing possibilities for a *cabildante* user:



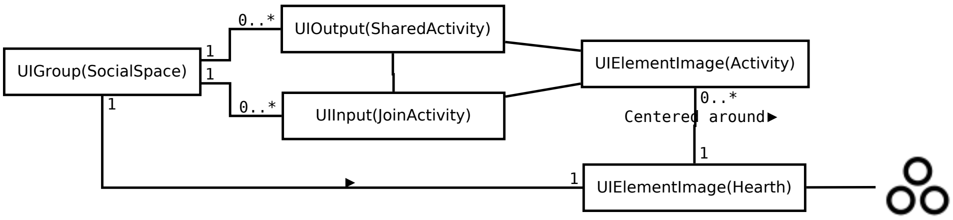
- A join task general to both user roles:



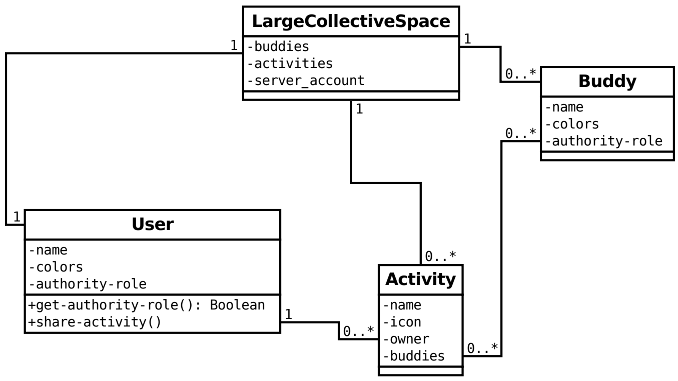
- Abstract Interactors and Concrete Images:
  - Share an activity



- Join an activity



- Classes:



Participants:

- Tasks:
  - **Share Task**: Abstract task to share (an activity) with other users.
    - **SelectPrivate**: Keep the task in a private space.
    - **SelectCloseInteractionGroup**: Share the task with a close-relationships group.
    - **SelectLargeCommunity**: Invite the whole community to work in the activity. This invitation may only be sent by a council member.
- Classes:
  - **User**: The computer user. Includes an *authority-role* attribute to determine whether he/she is a *cabildo* member or not.
  - **Buddy**: Any user connected to the system through the computer network.

  - **Activity**: Activity Class for any task available in the system.
  - **LargeCollectiveSpace**: Class representing the large interaction level space (*resguardo*), where the collective work is done. It comprehends all the *resguardo* users (Buddies) and all shared tasks.

Consequences: Non-*cabildante* users would have two options to share a task with others: Private or Inside a Limited group of Friends. The *cabildante*-user role would have an additional option: invite the whole *resguardo*. The application of this pattern does not have known drawbacks.

Known Uses: The design concept adaptation of the Sugar cooperative learning platform to the Nasa culture.

Related Patterns:

- Interaction spaces 9.4.2.
- Social Roles. Subsection 9.4.3.

Design Pattern: User's authority role

Intent: Take into account the possible user's social role, as a *cabildo* member.

Cultural categories:

- ***Social Organization:*** *Social Roles*. The *cabildo* (annually elected council) is the main authority in each Nasa *resguardo*.
- ***Non-verbal signs:*** *Common symbols*. *Cabildantes* (*cabildo* members) bear a *bastón de mando* (a black-wooden baton of command) representing authority.

Motivation: Each *resguardo* (Nasa territorial unit) is administered by a *cabildo*, an elected council in charge of administering, representing and solving conflicts, among others functions. The *cabildo* is composed of several people who have different roles: *gobernador*, *capitán*, *secretario*, etc.

Schools also have a *cabildo*, composed of students and which fulfills the same roles as the *resguardo*'s.

The users' authority role is important, especially in cooperative work-capable systems, because the work organization depends on the person who invites to work.

Options: A single option was considered in this design solution.

Criteria:

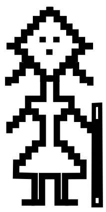
1. Consistency with cooperative work rules.

Evaluation: This pattern does not include an evaluation since only one option has been considered.

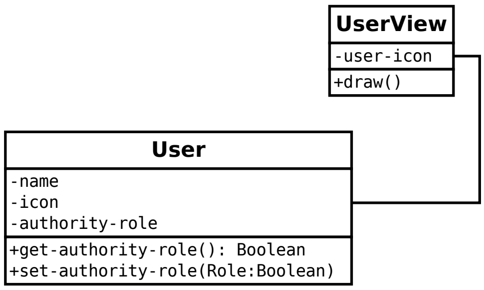
Applicability: Multi-User, Multi-Terminal, Cooperative Work-capable systems.

Structure:

- Concrete Graphical Representations:



- Classes:



Participants:

- Classes:
  - **User**: class representing the user model.
  - **UserView**: in charge of drawing the graphical representation of the user. Selects the right icon according the user's authority role.

Consequences: The application of this pattern does not have known drawbacks.

Known Uses: The Nasa Sugar adaptation. Cooperative work is organized according to the user's authority role.

Related Patterns:

- *Human Representation*, Subsection 9.4.1,
- *Share Tasks*, Subsection 9.4.3.

9.5 Conclusions

In this chapter we have explained the approach we used to describe a part of the consequences that sociocultural characteristics have on computer tool design.

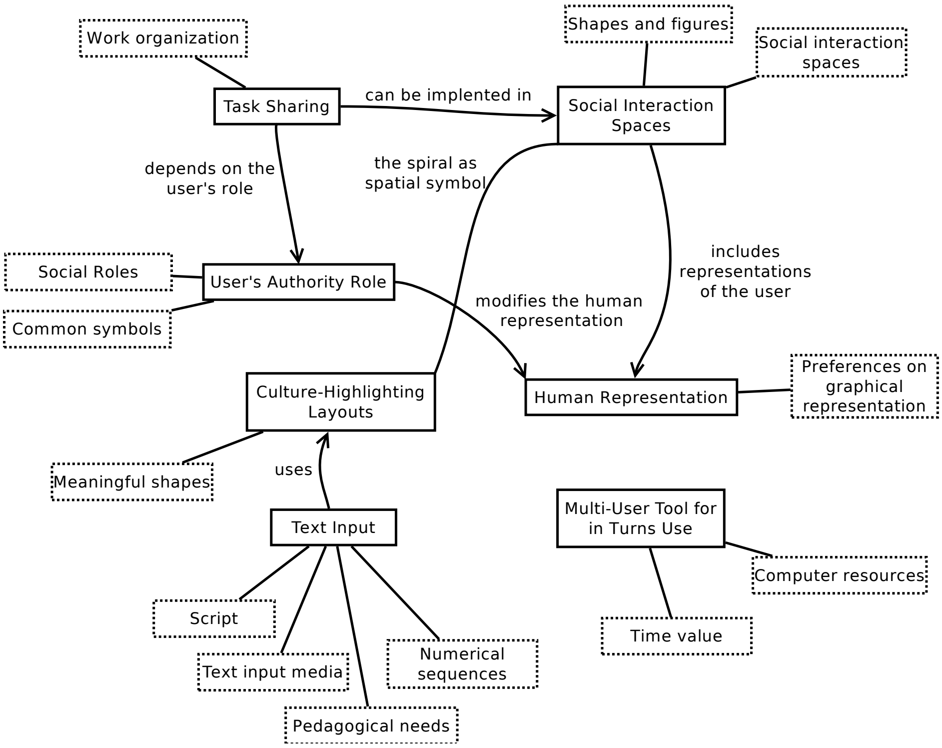


Figure 9.4: Design Pattern relationships and their related cultural characteristics.

The approach is based on Design Patterns enriched with Design Rationale descriptions. These two methods provide computer tool developers with reusable information about the design issues that we found and the solutions that we proposed to solve them.

The design patterns that we propose describe several aspects of the design solutions, including system models at different levels. To include interface design information, our approach also considers User Interface Design Patterns, describing the system's interface components, through models such as the *Tasks Model*.

Moreover, in order to describe the design decision process, these patterns are enhanced with Design Rationale-based information. This was inspired by the Question-Options-Criteria-Arguments (QOC) Model, relating the different options considered to solve a design problem (question), and the criteria taken into account in their evaluation.

Different design issues-solutions related to the design of computer tools for the Nasa people have been described in this chapter, including *how to provide a Nasa Yuwe text input mechanism in the interface*, *how to make use of the scarce computer resources available in the Nasa environment*, *how to replicate the social interaction levels in a multi-user multi-device system*, and *how to organize cooperative work according ot Nasa social rules*. This approach aimed at describing the cultural consequences studied through the cultural model and through the design of computer tools. Figure 9.4 summarizes the relationships between the different patterns exposed in this chapter.

It is important to note that certain sociocultural aspects overstep the scope of this description. Some such examples are the social organization influencing the evaluation methods or the influences authorities have on the development process.

Nevertheless, more than a method to describe reusable solutions to specific problems, the structure we formulate to describe patterns makes it possible to illustrate contextually grounded examples. The patterns showed here indicate the design question, the chosen solution as well as the context of them. The power of these structures is that the reader can understand how the solution were created in the context of the problem, can identify similarities and differences with reader's own problems and shape a solution accordingly.

Chapter 10

Conclusions and further work

> "Ya la comadre Caruca
> de tres piedras hizo el fogón"
>
> From a popular Cuban song by
> Celia Romero

As stated at the beginning of this manuscript, the motivation of this doctoral thesis was the influence of sociocultural differences between the users and developers on the design of computer tools. In this context, this thesis develops two contributions that aim at providing ICT experts with epistemic tools to integrate users' sociocultural characteristics in computer tool designs. Despite the fact that the thesis' results are independent of the users' context, the application of the contributions focused here on the Nasa Colombian indigenous people. Cultural particularities of this society gave the initial insights to formulate our research questions.

According to bibliographical research, we concluded that these cultural differences may provoke, at least, three different types of consequences on computer tool design: (1) representation and signification, (2) prototype evaluation methods and (3) quality criteria. However, most of the outcomes of our work has resulted in the scope of representation issues, being the most accessible to study.

If we consider the metaphor HUMAN-COMPUTER INTERACTION IS A COMMUNICATION PROCESS BETWEEN THE SYSTEM USER AND THE DEVELOPER, we can outline how important the possible cultural differences are. As shown in Chapter 4, communication and signification processes largely depend on the cultural background of the two involved actors.

> From that metaphor, we can identify a design conclusion: ICT experts must elaborate communication *codes* considering the users' *context*, to facilitate the *message* exchange taking place through the interface.

Implementations of this thesis' contributions aimed at a Nasa specific need: the use of ICT to support education efforts focusing on language and culture revitalization. Consequently, two design concepts were evaluated with Nasa students and teachers: a pedagogical game based on local toys and a cooperative learning platform.

10.1 Research questions and contributions

As previously stated, this study aimed to answer to research questions:

1. *What should we study about the users sociocultural context if we need to develop pedagogical computer tools?*
2. *How to describe the influence of the users' culture on interactive system design?*

These questions has been tackled through two main contributions:

1. A sociocultural modeling approach aimed at developing pedagogical computer tools
2. An approach to describe interactive tool design knowledge

Answering to these research questions, we searched to related two types of models: the cultural model in one hand, and the interactive tool design modeling on the other hand. Then, the last objective of our contributions was to allow ICT experts knowing that, under a determined sociocultural context, a design solution is better than another one to solve a design issue.

We can also see this research objective as a communication-related problem between ICT experts: the thesis objective is to provide a *code* allowing computer tool designers to describe and exchange knowledge regarding the design of tools for a specific cultural context.

10.1.1 A sociocultural modeling approach aimed at developing pedagogical computer tools.

This contribution aims at allowing ICT experts to discern from the users' culture the characteristics with possible influences in the design of computer tools. In other words, it gives an answer to the first research question.

Our approach is based on existing well-known cultural models, described in Chapter 3, that could not be directly applied since they have different foci that ours. Nevertheless, we have selected and adapted their components to compose a sound base to construct our own modeling approach. Considering the types of culture-design consequences described above —representation, evaluation methods and quality criteria—, the resulting model consist of five broad variables: (1) *written and oral language*, (2) *spatial structures*, (3) *social organization*, (4) *environment and technology* and (5) *nonverbal signs*.

To summarize, we can consider some examples of the cultural consequences these dimensions permit to consider. Through the **written and oral language** dimension, we can study and then implement appropriate support for character representation, text handling and interface directionality. The **spatial structures** could guide the design of individual and collective interface SPACES. The **social organization** dimension helps in determining the computer support to facilitate users accomplish collective tasks according to social rules; or to elaborate education tools according to pedagogic policies and needs. The **environment and technology** dimension covers the identification of requirements with respect to the technology conditions where the computer tool would be used. For example: (1) limitations in internet access and computing capabilities, or (2) the computer literacy level of teachers and school staff that would be responsible for giving technical support once the tools have been deployed. This dimension also helps to study local resources that could serve as metaphor objects. The **nonverbal signs** dimension aims to determine interface elements such as shapes, colors, gestures and other representation characteristics. Preferences on representations that could impact the tool evaluation criteria are also part of this dimension.

The application of this cultural model to study a specific society results in a set of hypotheses and conclusions with respect to the consequences of the users culture on the interactive tool design process.

As shown in Section 7.2, we have studied the Nasa culture through this model. The resulting design hypotheses and conclusions were evaluated through in-field work in two contrasting Nasa schools. During this in-field work, Nasa teachers and students participated in the design concept evaluation of two different tools aimed at theirs schools. It must be pointed out that, given the evaluation conditions, it was difficult to carry out a statistical evaluation, and thus, we opted for a qualitative observation approach.

To give a final conclusion regarding this contribution, we can consider the three del Galdo-Nielsen levels of computer tool cultural adaptation (del Galdo and Nielsen, 1996, p. v). We can conclude that this model help ICT experts to produce tools concerning the three levels, since it takes into account language related issues (first level), graphical preferences and evaluation methods (second level) and how task are accomplished by a group of users (third level).

10.1.2 An approach to describe interactive tool design knowledge

The second contribution aims at representing the consequences of particular cultural characteristics in the design of computer tools. To be more precise, this approach seeks to describe the experience and solutions to solve specific design issues when the users' culture is considered.

As we have concluded in Chapter 9, we have taken into account three different but complementary supports to construct our approach: (1) interactive tool design models, (2) design patterns and (3) design rationale. This approach provides a semi-formal structure to relate cultural characteristics to MDA-based models and design process information. In this way, we can provide further developers with information about how to solve users' sociocultural context-related design issues with reusable solutions.

It is important to note that this approach is possible thanks to the evolution and on-going development of interactive system modeling. As shown in Chapter 5, computer system models have gained granularity and different abstraction levels through the years. However, we have decided to dismiss a specific interface-user modeling approach since they still need to reach a maturity state.

To conclude, this approach has capabilities to describe three aspects of the design process: (1) the description of different levels of interactive system modeling, (2) part of the solution design experience and (3) alternative solutions and the reasons to choose among them.

10.2 Discussion

As previously described, two types of hypotheses were considered in this thesis: (1) a general research hypothesis formulated in Section 7.1.6 and shown below and (2) a set of Nasa-specific design hypotheses, whose results were described in Chapter 8.

Thesis' general research hypothesis: The interactive tool design models and description methods considered in this thesis can describe the culture-design consequences identified through the modeling of the users' sociocultural characteristics.

In order to evaluate the general research hypothesis, we must consider: (1) the different types of consequences that the cultural model allows to abstract —representation, evaluation methods and quality criteria— and (2) the description capability of the second contribution.

First, the representation consequences include computer characteristics related with the elaboration and interpretation of interface signs. Examples include: layouts of concrete graphical elements, graphical tools for text inputing, interface structures according to social rules, among other. These characteristics can be represented, in different levels of detail, through the various computer system models. Nevertheless, it is necessary to give more formality to the description of graphical layouts.

Second, quality criteria and their impacts on design can be described through the semi-formal structures of design patterns, or by the more formal representations provided by the QOC design rationale model. We can consider two examples: (1) the preferences on graphical representations, which are the criteria to evaluate two type of images in the Nasa context (See Pattern 9.4.1), and (2) the culturally meaningful shapes that highlight the relationship of the computer tool with the users' culture. The use of these shapes makes the users positively evaluated the maize (See Pattern 9.2.2). Therefore, we can affirm that, for this type of culture-design consequence, the general research hypothesis is confirmed.

Third, evaluation methods and other development process are unsupported by our description approach. Thus, for the moment, we refute the general hypothesis for this type of culture-design consequence.

10.2.1 Limits of the validation

We can outline the limits of the validation of the two types of hypotheses listed above.

First, with respect to the general research hypothesis, main limitations are found in the representation and signification consequence type. The validation of the hypothesis in regards to this representation aspect is limited by the description capability of the interactive system models considered in this thesis. For example, one of the cultural characteristics beyond of the description capability is related to computer skills. It was observed that *drag-and-drop* was a difficult interaction technique for Tumbichucue children compared to Caldono students. We hypothesize that, since Tumbichucue students have had less contact with computer than their Caldono colleagues, pointing and clicking techniques were more suitable in low computer skill contexts. Thus, other HCI-related models, such as an interaction technique model, should be also considered.

Second, with respect of the Nasa-specific design hypotheses, summarized in Section 8.5.3, their validation has been limited by the evaluation conditions. One one hand, as previously stated, the representations issues have been the easiest to study. On the other hand, during in-field work we faced obstacles that prevent us to stay a longer time in Nasa territory and carry out planned activities, especially those concerning the comparison of evaluation methods. These limitations in time made also difficult to execute a complete evaluation on how Nasa users assign computer tool quality criteria.

10.3 Perspectives

We can identify directions for further work in different aspects concerned by this thesis.

Characterize other cultures through the cultural model: A first perspective is the necessity to evaluate the cultural model in other contexts and compare the results from the Nasa modeling. Despite the fact that to construct the model dimensions we have considered works concerning diverse cultural contexts, an complete model evaluation in one of them would permit to carry out a more precise evaluation of the approach. Since the current political situation in Colombia claims to support indigenous language revitalization, it would be interesting to characterize other Colombian native communities. This would make it possible to compare the possible similarities of education computer tools.

Computer tool evaluation methods: Second, the evaluation of exogenous computer tools and the evaluation of design concepts have been carried out through qualitative observations. We think it is necessary to develop more formal methods. However, we have to bear that, in the scope of the development of pedagogical computer tools for sociocultural context such as the Nasa, design and evaluation approaches have to consider different challenges, including: (1) the evaluation methods with children from another cultural background, (2) collective prototype methods, comprising the place of elders, teachers and other authorities and (3) the geographical distance with the target public, among others.

Interactive design modeling as a signification system: Another important perspective is the use of semiotics structures to describe computer system components. As we have described in Chapter 4, the semiosis-based representations can related different computer tool components. We can consider the different abstraction modeling levels proposed by MDA to describe the signification relationships of the Paste function, as shown in Figures 10.1 and 10.2. These figures show how the same *object*, «assign location to an object» is related by different signs according to the users' cultural context.

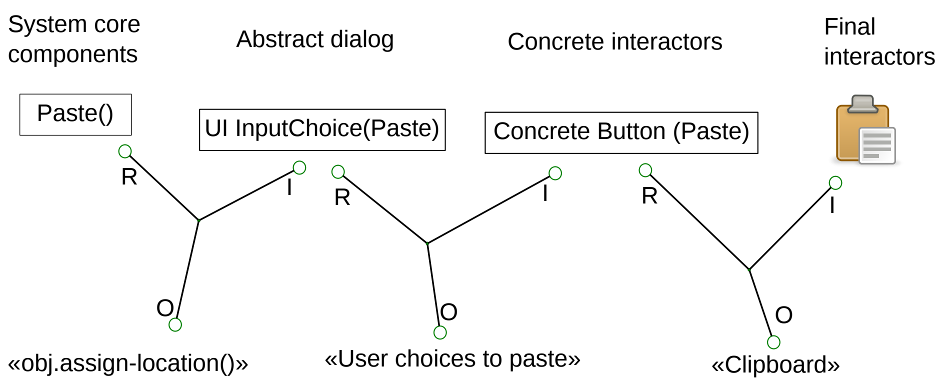


Figure 10.1: Signification relationships between different computer system components, which relate a /clipboard graphical icon/ to the «obj.assign-location» function in a computer-expert cultural context.

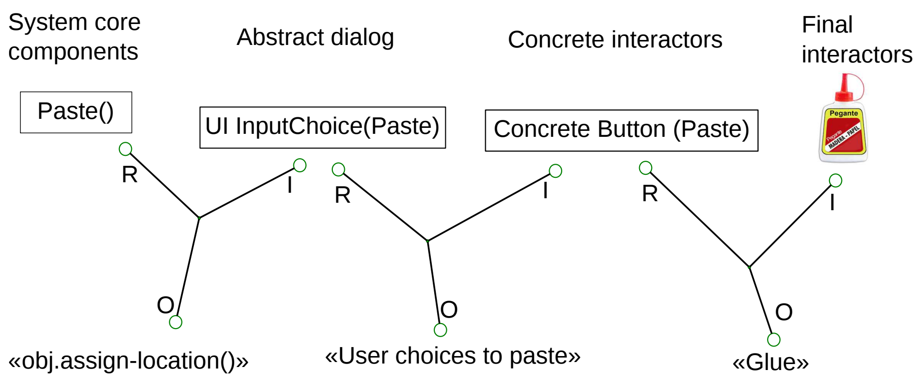


Figure 10.2: Signification relationships between different components of a potential computer system, relating a /glue graphical icon/ to the «obj.assign-location» function in the Nasa cultural context.

We think that this kind of representation would be useful to create interfaces with the ability to adapt themselves to represent the same *object* according the user's cultural context. A similar system would give support to the third del Galdo-Nielsen level of computer tool cultural adaptation.

In this perspective it would be important to consider if whether the explicit *representation* of the *object* in each triad is useful or not. What we can handle as object in the triad is just another representation (another sign) of the same object.

Finally, we can summary the contribution of this thesis in de Souza (2005)'s words: what we have tried to construct is to leave "traces of the designer's rationale."

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L'intégration de facteurs culturels dans la conception d'interfaces utilisateur: le cas du peuple aborigène colombien nasa

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1 Introduction

Le cadre de recherche de cette thèse est le développement d'outils informatiques dans un contexte inter-culturel. Elle prend comme cas d'étude le peuple nasa, aborigènes de Colombie, qui conserve de multiples traditions et des caractéristiques culturelles importantes. Grâce au travail précédent réalisé par CHECA HURTADO et RUANO RINCÓN (2006), nous pouvons identifier les besoins de recherche qui guident cette thèse. Un effort de traduction du lexique informatique dans la langue nasa n'a pas eu les résultats prévus, mais a permis l'identification d'un manque de compréhension des signes permettant l'interaction. Par exemple, l'interface de base de l'ordinateur personnel, la métaphore du bureau, a été conçue pour un contexte particulier, différent à l'environnement rurale des populations telles que les nasa. Le bureau, les dossiers, fichiers et d'autres composants de la métaphore ne sont pas courants chez les nasa. Au-delà de la langue écrite utilisée dans l'interaction, qui dans ce cas diffère de la langue maternelle des utilisateurs, les éléments principaux de l'interface sont utilisés avec certains limitations.

Nous avons donc identifié le besoin d'étude socioculturel et de productions d'outils le plus proches possible de la culture des utilisateurs.

En conséquence, l'objectif visé par la thèse est de fournir un *framework* pour aider les producteurs d'outils à mettre en œuvre des processus de conception dans un contexte socioculturel spécifique et différent des leurs. Autrement dit, nous cherchons à produire un soutien théorique pour la conception qui permettra de guider la sélection des composants du système adaptés à la culture des futurs utilisateurs.

Plus précisément, cette thèse cherche a répondre à deux questions de recherche : (1) *Que faut-il étudier du contexte socioculturel des utilisateurs pour le développement d'outils informatiques ?* et (2) *Comment décrire l'influence de la culture des utilisateurs sur la conception d'un système interactif ?*

Ce document synthétise les résultats que nous avons obtenus lors de ce projet. La section suivante introduit le peuple nasa. L'état de l'art est décrit entre les Sections 3 et 6. Ensuite, les Sections 7, 8 et 9 sont consacrées aux contributions réalisées pour répondre à la problématique de recherche. Enfin, la dernière section résume les conclusions les plus importantes du travail de recherche.

2 Le contexte d'étude : le peuple nasa

Le contexte d'étude de cette thèse est centré sur le peuple nasa, indigène du territoire colombien. Nous synthétisons dans ce document les principales caractéristiques du peuple nasa que nous avons considérées. Un des objectifs de cette thèse est de prendre en compte des facteurs culturels au-delà de la représentation textuelle, le langage écrit, les formats des chiffres, et d'autres qui sont, en générale, le plus communs dans les processus d'adaptation d'un outil à un contexte culturel spécifique (GALDO et NIELSEN, 1996). Dans notre approche, nous avons pris en compte une large gamme d'aspects, tels que le contexte géographique, l'organisation du travail ou les éléments symboliques.

Cette section introduit de façon générale la culture nasa. D'autres caractéristiques socioculturelles nasa seront décrites entre les Sections 7 et 8. Pour l'instant, il est importante de spécifier que le nasa est un peuple agraire, semi-isolé de la société urbaine-industrialisée, ils ont une organisation sociale, des institutions d'autorité et une organisation de travail propres.

Concernant la situation géographique, les nasa habitent dans des différents communautés réparties sur les deux flancs de la cordillère centrale des Andes, dans le sud-ouest du pays. Chaque communauté partage un territoire appelé *resguardo*, où la plupart de la population, mène une vie agraire et centrée sur l'agriculture.

Les nasa ont aussi une langue maternelle, appelée *nasa yuwe*. Le nasa yuwe prend une considération importante dans l'éducation et les politiques car son usage est en train de diminuer. Les autorités nasa cherchent à fortifier la langue à travers d'une éducation bilingue dans les écoles. En conséquences, un des besoins auquel l'informatique peut répondre est le développement d'outils qui aident à l'apprentissage et revitalisation de la langue nasa. Outre que la langue, il existe aussi d'autres formes de représentation à souligner. Par exemple, le losange et la spirale sont de symboles de signification importante et présents dans des diverses manifestations artistiques.

Comme il a été dit précédemment, la considération seulement de la langue reste incomplet dans un processus de conception. Nous avons donc étudié l'état de l'art de méthodes pour la caractérisation des facteurs socioculturels dans un sens plus large.

État de l'art

L'état de l'art choisi pour développer la thèse concerne deux grandes parties qui visent les deux axes de recherche. La première partie, comprise dans les Section 3 et 4, concerne l'étude de la culture et la compréhension de la problématique du point de vue théorique. La seconde s'inscrit dans les méthodes de description et représentation d'un système interactif et son processus de conception, décrits dans les Section 5 et 6. L'objectif général est d'intégrer ce deux axes.

3 Modélisation de la culture

Avant d'aborder la problématique de la modélisation culturelle, il est nécessaire de définir ce que nous entendons par « culture », tâche assez complexe si nous prenons en compte que, selon KROEBER et KLUCKHOHN (1954), cette notion compte plus de 300 définitions différentes. La thèse prend en compte plusieurs concepts pour définir culture comme : *collectively learned system of significations and behavior, consisting of thoughts, feelings and actions*[1].

Il est important de souligner trois aspects de cette définition : (1) la culture est apprise et partagée par les utilisateurs d'un même groupe social ; (2) la culture influence l'interprétation des signes qui composent les interfaces humain-machine, comme nous le décrivons dans la section suivante ; (3) elle agit également sur la manière d'utiliser les outils, et sur la participation des utilisateurs dans les méthodes de développement. À partir de cette définition, nous cherchons à modéliser le contexte socioculturel des utilisateurs. Les travaux sur que nous avons considérés à ce sujet peuvent être classifiés en deux catégories, selon leur orientation : (1) la résolution de problèmes humains et les systèmes de valeurs, et (2) la communication et le comportement inter-culturels.

Dans la première catégorie nous trouvons les travaux de recherche de : KLUCKHOHN et STRODTBECK (1961), HOFSTEDE (2005) et TROMPENAARS (1993). Kluckhohn et Strodtbeck se sont intéressé aux systèmes de valeurs de une société sous des différentes orientations afin d'étudier, par exemple, les liens entres les êtres humains (individuel, linaire ou collatéral) ou leurs rapports avec la nature. À son tour, Hofstede a conçu un modèle composé de quatre variables : la distance hiérarchique, l'individualisme versus le collectivisme, l'acceptation de l'incertitude, et la dimension masculine versus féminine. Selon Hofstede, ces variables aident à identifier les différences dans ce qu'il appelle la programmation mentale. Le troisième modèle dans cette catégorie est celui de Trompenaars, qui définit la culture comme *« the way in which a group of people solves problems and reconciles dilemmas*[2]. »Il regroupe les types de problèmes dans trois catégories : les problèmes dans les rapports avec les autres, les problèmes à cause du passage du temps et les problèmes avec un lien avec l'environnement.

1. Un système de significations et comportements, acquis collectivement et composé de pensées, sentiments et actions.
2. La manière dont un groupe de personnes résout ses problèmes et réconcilie ses dilemmes.

En ce qui concerne la thèse, ces variables peuvent nous aider à étudier la place donnée aux outils informatiques pour la résolution des problèmes. Faut-il comprendre les ordinateur dans un contexte de travail individualiste ou collectiviste ?

La catégorie de communication et comportement interculturels comprend les travaux de Edward Hall et VICTOR (1992). Hall modélise la culture selon six grandes variables : le contexte, la vitesse des messages, l'espace, le temps, le flux de l'information et les chaînes d'action. De son côté, David Victor a développé le modèle *LESCANT*, acronyme des sept dimensions prises en compte : le langage, l'environnement et technologie, l'organisation sociale, le contexte, l'autorité, le comportement non-verbal et le temps. Ces modèles visent à fournir un cadre de travail pour la formulation des questions appropriées dans le contexte d'affaires internationales, où les différences culturelles jouent un rôle essentiel.

Nous pouvons observer que les modèles de ces auteurs couvrent des aspects divers pour étudier une culture, différences qui sont données par les variations dans les objectifs visés par chaque modèle. Les modèles que nous avons considérés sont centrés sur les affaires et sont imprécis dans le cadre du développement d'outils informatiques. Cependant, nous pouvons les prendre comme une base et adapter leurs variables selon nos besoins de recherche.

Les aspects compris par ces modèles ont été analysés selon l'influence de la culture identifiée pendant le travail avec la pupulation nasa, la recherche bibliographique, et les résultats obtenus par d'autres auteurs au sein d'autres contextes socioculturels. Le modèle résultant est décrit dans la Section 7.

4 La sémiotique et l'interaction humain-machine

La sémiotique –l'étude du signe, de la signification et de la communication– permet de comprendre une partie de la problématique concernée par la thèse. La place de la sémiotique dans l'étude de l'interaction humain-machine est illustrée par des auteurs tels que DE SOUZA (2005) et NAKE et GRABOWSKI, 2001, qui affirment que les interfaces des systèmes interactifs sont composées par des signes : des mots, des gestes, des sons, des images, etc. Le signe, concept de base dans la sémiotique, est défini par Charles S. Peirce comme « textitsomething which stands to somebody for something in some respect of capacity. . . [3] (PEIRCE, 1931-1958). »Les signes qui conforment l'interface sont élaborés par les producteurs de systèmes interactifs et interprétés par les utilisateurs des outils. Ce concept, selon DE SOUZA (2005), nous permet de comprendre que l'interprétation des signes dépend partiellement de la culture de l'utilisateur.

Ainsi, l'interaction entre les êtres humains et les machines présente certaines similitudes avec un processus de communication. Il est important de souligner ceci car, comme argumenté par ECO (1976), le processus de communication concerne

3. Signe : quelque chose qui tient lieu pour quelqu'un de quelque chose sous quelque rapport ou à quelque titre. Traduit par DELEDALLE (1990, p. 24)

un système de significations, qui, à son tour, est basé sur des conventions culturelles.

En conséquence, la sémiotique nous permet de comprendre un des problèmes de recherche : l'interprétation des signes qui composent l'interface, dépend largement du contexte socioculturel des utilisateurs. Nous devons donc considérer comment les utilisateurs de contextes socioculturels différents au notre interprètent les signes que nous concevons pour permettre l'interaction avec les outils.

5 Modélisation d'un système interactif

La seconde partie de la base théorique correspond à celle des méthodes pour représenter un système interactif et son processus de conception. Nous en avons besoin pour y intégrer l'influence du contexte socioculturel des utilisateurs et répondre à la seconde question de recherche. Le problème direct lié à cette question concerne les choix de conception. Comment permettre aux futurs producteurs d'outils de faire usage des connaissances sur l'influence de la culture d'un groupe d'utilisateurs particulier ? En conséquence, nous avons besoin de décrire le système de manière à ce que d'autres développeurs puissent le comprendre. En outre, il est nécessaire de décrire les rapports entre les composants des outils et les différentes caractéristiques culturelles que les ont motivés.

Afin de résoudre ce problème de recherche, nous avons étudié différentes méthodes pour représenter un système interactif ainsi que son processus de conception. Cette section est dédiée à la modélisation du système. La représentation du processus sera abordée dans la partie suivante.

Nous pouvons identifier trois catégories de modèles de systèmes interactifs cités dans la bibliographie : (1) les modèles orientés aux tâches, (2) les modèles centrés sur l'architecture et (3) les architectures orientées aux modèles. L'évolution de la modélisation est représentée dans ces trois catégories.

Modèles orientés aux tâches. Selon LIMBOURG, PRIBEANU et VANDERDONCKT (2001), une tâche est une activité réalisée par l'utilisateur afin d'accomplir un but spécifique. Plusieurs modèles de ce genre ont été développés pour décrire les tâches que l'utilisateur peut accomplir au travers de l'usage d'un système interactif. Comme exemples de ces modèles nous pouvons citer : GOMS, User Action Notation (UAN), CTT, K-MAD et BPMN. En comparant ces trois modèles, nous pouvons observer comment leur centre d'intérêt a évolué. Les premiers modèles de tâches furent focalisés sur l'exécution d'une tâche dans un système déjà opérationnel. Les modèles plus récents sont, par contre, orientés à la résolution des problèmes, ils considèrent des niveaux d'abstraction plus élevés, et peuvent prendre en compte des problèmes cognitifs et les processus métier.

Ces modèles pourraient fournir une manière de décrire les variations entre différentes cultures dans la réalisation d'une tâche en utilisant l'ordinateur. Cependant, ils sont insuffisants pour exprimer les possibles représentations qui ont lieu à travers l'interface.

Modèles centrés sur l'architecture. Ces modèles prennent en compte les composants d'interaction avec l'utilisateur. Exemples de ces modèles incluent : Seeheim (PFAFF, 1985), MVC (KRASNER et POPE, 1988), PAC (COUTAZ, 1990) et Arch (UIMS, 1992). À travers leurs évolution, les modèles ont gagné en granularité par rapport aux composants de l'architecture, considérant différentes entités qui permettent la communication entre l'utilisateur et le noyau de calcul.

Architectures orientées aux modèles. Un changement de paradigme a eu lieu au début des années 2000, quand l'Object Management Group a introduit l'Architecture dirigée par modèles (MDA), qui structure la conception de systèmes informatiques selon des modèles. MDA a pour objectif le support des méthodologies pour l'ingénierie dirigée par les modèles (MDE) qui place le modèle du domaine au centre du processus de conception. Des approches qui considèrent cette orientation et la conception d'interfaces utilisateurs incluent : RML, PERCOMOM et UsiXML.

Un des aspects les plus importants de ces architectures est l'identification des différents niveaux d'abstraction dans l'interaction et ses modèles correspondants, tels que le modèle indépendant du calcul, le modèle indépendant de la plateforme et le modèle spécifique de la plateforme. En ce qui concerne la thèse, ce degré d'abstraction nous permettrait de représenter l'influence de la culture sur les différents composants du système.

Malgré leurs avantages, ces approches sont en cours de développement et ils ont besoin d'atteindre un niveau de stabilité et de maturité.

6 Méthodes de description de conception

Comme il a été dit précédemment, il est important aussi de pouvoir décrire l'influence de la culture dans les différentes étapes d'un processus de conception. Différents approches existent pour illustrer les raisons, les conséquences, les avantages et désavantages d'une solution de conception par rapport à une autre. Ici, nous avons considéré deux méthodes différentes : les patrons de conception et la logique de conception [4].

Patrons de conception. Ces patrons sont définis comme des solutions réutilisables pour résoudre des problèmes récurrents. Originalement conçus dans le domaine de l'architecture (ALEXANDER, 1977), les patrons de conception ont été adaptés à des différents domaines de travail. En sciences de la computation, les patrons ont gagné de la popularité à partir des travaux réalisés par GAMMA et al. (1995). Certains développements ont été faits dans le champ spécifique de l'interaction humain-machine, par exemple : RADEKE et FORBRIG, 2007 et VANDERDONCKT et SIMARRO, 2010.

4. *Design Rationale*

Les patrons de conception sont représentés par une structure de quatre composants essentiels : *identification*, *problème, solution* et *conséquences*. Cette structure présente des variations et différents degrés de formalité en fonction de l'approche et le domaine.

Logique de conception. Il s'agit d'une méthode de documentation qui décrit les arguments, alternatives et décisions pris en compte derrière un processus de conception. Il a été introduit par WERNER et RITTEL (1970) pour donner une structure aux arguments des processus cherchant à résoudre des *wicked problems* [5]. Selon MORAN et CARROLL (1996), la logique de conception cherche à exprimer les raisons réelles de la conception. Il existe des différentes méthodes de logique de conception, tels que *IBIS* et *QOC*. Une approche comme *QOC* peut être utilisée pour documenter l'information concernant les décisions prises pour évaluer une solution, où les facteurs culturels peuvent faire partie des arguments.

Nous considérons les patrons et la logique de conception comme des outils complémentaires qui permettent d'enrichir l'information autour de la conception.

Contributions

Cette partie présente les contributions réalisées pendant la thèse pour répondre aux deux questions de recherche. Le modèle culturel décrit dans la section suivante est un outil d'aide à l'étude du contexte socioculturel des utilisateurs. Ce modèle a été évalué au travers de la conception participative, dans le territoire nasa, de deux outils informatiques. Nous avons développé également une approche pour décrire l'influence de la culture dans les processus de conception. Approche qui est décrite dans la Section 9.

7 Modélisation du contexte socioculturel des utilisateurs pour la conception d'outils informatiques

Cette section décrit le modèle culturel élaboré pour caractériser le contexte des utilisateurs afin de concevoir des outils informatiques. Ce modèle a été développé à partir des travaux sur la modélisation culturelle décrits dans la Section 3. Le modèle que nous formulons est composé de cinq dimensions : (1) *le language oral et écrit*, (2) *l'organisation sociale*, (3) *les structures spatiales*, (4) *l'environnement et la technologie*, et (5) *les signes non-linguistiques*. Pour illustrer ces dimensions dans ce résumé, nous décrivons comment elles nous permettent de caractériser la culture nasa et de formuler des hypothèses et conclusions autour de la conception d'outils pour cette population.

5. Problèmes épineux

La dimension **langage oral et écrit** s'intéresse, par exemple, à comment l'alphabet, la direction de l'écriture, l'ordre alphabétique et le système d'écriture en général peuvent influencer la conception du système. Elle étudie comment le texte doit être manipulé par les composants chargés de la computation et représenté sur les interfaces écrites. Par exemple, le sens de l'écriture (de gauche à droite et de haut en bas, ou de droite à gauche et de haut en bas) dessine la configuration des éléments dans les interfaces, comme il est illustré par MEDHI, SAGAR et TOYAMA (2006, p. 40).

Le nasa yuwe et son impact dans la conception de l'interaction : Il est important de souligner que la culture nasa était un peuple à tradition orale. À partir d'un processus d'unification, le système d'écriture a été approuvé par la communauté en 2001. L'alphabet de la langue nasa est composé de 69 graphèmes —32 voyelles et 37 consonnes— basés sur les caractères de l'alphabet latin (ROJAS CURIEUX, 2002). Il y a deux groupes de voyelles, orales et nasales (différenciées par la tilde (˜) sur les dernières) et un nombre de consonnes « basiques » : p, t, ç, k, m, n, b, d, z, g, l, s, j, y et w. Selon les phénomènes phonétiques qu'ils représentent, les graphèmes peuvent être des graphes simples, digraphes ou trigraphes : i, a, ç, e', ah, ĩi, çx, ph, txh.

D'un autre côté, le système d'écriture a des caractéristiques qui, pour l'instant, n'ont pas été normalisées. Par exemple, les nasa n'ont pas pris de décision sur l'ordre alphabétique. En conséquence, dans ce résumé nous pouvons formuler la conclusion suivante concernant le nasa yuwe :

> Conclusion de conception : il n'est pas possible de distribuer des éléments dans l'interface selon un ordre alphabétique.

L'organisation sociale est une large dimension. Elle observe, par exemple, comment l'utilisation de l'ordinateur peut être articulée par rapport à l'organisation du travail, aux institutions d'autorité, etc. Cela peut être manifesté sur la conception d'un usage des outils individuel ou collectif, sur comment permettre l'exécution de tâches selon les rôles sociaux ou configurer l'accès aux données selon les politiques de confidentialité.

L'organisation sociale peut influencer aussi les méthodes de développement. MEDHI, SAGAR et TOYAMA (2006), WINSCHIERS-THEOPHILUS (2009) or GORMAN et al. (2011) détaillent des exemples, où dans des sociétés à orientation de travail collectif, les méthodes de conception et d'évaluation en groupe donnent des résultats plus riches que les individuelles.

L'organisation sociale chez les nasa : Selon les descriptions de PACHÓN C. (1996), ROJAS CURIEUX (1996), les formes de travail collectif prédominent sur les individuelles. Participer au travaux dans le groupe est une manière importante de ratifier l'appartenance à la communauté.

Le travail est organisé en fonction d'invitations. Suivant leur rôles sociaux, les individus sont en capacité d'inviter d'autres membres de la communauté à travailler sur une tâche déterminée. Par exemple, le *cabildo* peut convoquer la réalisation d'une œuvre à intérêt commun, où chaque famille du *resguardo* doit y participer. En ce qui concerne la production d'outils informatiques, nous pouvons donne l'exemple d'un système multi-utilisateurs conçu pour supporter le travail coopératif selon ces règles.

L'importance du travail collectif nous permet d'établir des besoins pour concevoir des outils pour les écoles nasa. Comme nous décrivons dans la section suivante, nous proposons la conception d'une plateforme multi-dispositifs de travail coopératif. L'hypothèse de conception suivante sera évaluée sur terrain [6] :

> Hypothèse de conception 1 : les élèves et enseignants des écoles nasa sont d'accord pour le concept d'un système informatique capable de supporter le travail coopératif selon les règles sociales et les invitations à travailler.

La dimension des **structures spatiales** est dédiée à l'étude des possibles espaces d'interaction sociale qui pourraient donner lieu, au travers des métaphores, à des moyens d'interaction dans l'outil informatique. Cette dimension considère aussi la place des dispositifs dans les différents endroits où les utilisateurs interagissent, en prenant en compte les frontières personnelles ou collectives. Dans ce sens, GREENBERG (2011) affirme que les normes des distanciation interpersonnelle peuvent être appliquées à la conception de tables numériques collaboratives.

Les structures spatiales nasa et leur influence dans l'interface. Nous pouvons identifier deux espaces d'interaction sociale importants chez les nasa : le foyer à trois pierres (la *tulpa*, élément essentiel et central dans les maisons) et le territoire communal (le *resguardo*). D'après PACHÓN C. 1996 ; LASSO SAMBONY et CALAMBÁS SÁNCHEZ, 2005, la *tulpa* constitue le premier espace d'apprentissage, où la famille partage au moment des repas, et où les plus anciens transmettent leur connaissances aux plus jeunes. De son côte, le *resguardo* est la principale unité territoriale et politique, inaliénable et de propriété collective. C'est dans les *resguardos* que les communautés aborigènes colombiennes bénéficient d'une certaine autonomie juridique qui leur permet d'exercer les traditions et coutumes.

Un exemple concret de l'utilisation de ces deux structures est la représentation des espaces d'interaction dans un système multi-utilisateurs. Le foyer et le *resguardo* peuvent être reproduits dans l'interface comme des endroits de partage et d'apprentissage collectif. En conséquence, nous pouvons formuler une hypothèse à évaluer sur terrain au travers la conception d'un outil :

> Hypothèse de conception 3 : les utilisateurs évaluateurs nasa comprennent la métaphore qui représente dans l'interface les espaces collectifs centrés sur les foyer à trois pierres.

La dimension **environnement et technologie** étude la nature de l'environnement et les ressources techniques disponibles dans les endroits où les individus vivent et travaillent, ainsi que leur places au sein de la société. Cette dimension est basée principalement sur celle du modèle de Victor, qui définit environnement

6. Le numéro d'identification de hypothèses correspondent à ceux du manuscrit de la thèse.

comme *« the physical elements —both natural and human-made— that surround a person...*[7] »(VICTOR, 1992, p. 46). Dans cette dimension, nous considérons les ressources quotidiennes, ludiques et de travail, ainsi que l'environnement prédominant. Reprenons comme exemple le bureau, les fichiers, la corbeille (et le concept de recyclage) ainsi que d'autres objets typiques d'un contexte urbain et bureautique, qui ont inspirés des éléments semblables dans l'interface des ordinateurs personnels.

D'un autre côté, cette dimension prend en compte les ressources directement liés à l'usage de dispositifs informatiques : la disponibilité d'énergie électrique, l'accès à internet ou le ratio d'ordinateurs par personne. Un exemple à souligner de comment il est possible d'utiliser de ressources limités dans un environnement rural est illustré par GAIKWAD, PARUTHI et THIES (2010). Les auteurs ont développé des outils interactifs qui sont utilisés sur des TVs et lecteurs DVD, équipement plus courant que les ordinateurs dans l'environnement des utilisateurs.

L'environnement la situation technologique nasa : Comment dit précédemment, l'environnement nasa est principalement rural et les ressources quotidiennes disponibles sont celles d'une vie agraire. Il est important d'observer aussi, qu'au moment du développement de cette thèse, les ressources informatiques sont limitées. Certains communautés ne possèdent pas de l'énergie électrique permanente et l'accès à internet est restreint. En général, nous pouvons affirmer que les ordinateurs ciblent un public castillanophone.

Une conséquence liée au *langage oral et écrit*, est le manque d'un support complet pour l'écriture en nasa yuwe. Les ordinateurs et claviers sont dépourvus du moyen de saisie des voyelles nasales et la lettre ç :

> Conclusion de conception : il est nécessaire de fournir un moyen dans l'interface graphique des ordinateurs personnels pour permettre l'écriture en nasa yuwe.

La dimension des **signes non linguistiques** comprend touts les symboles visuels, auditifs, quantitatifs, gestuels et des autres sortes relatifs à une signification pendant l'interaction avec les machines. Par exemple, les couleurs peuvent être liées à certains évènements, comme le rouge pour fermer une session ou notifier à l'utilisateur une alarme, de même le vert peut montrer le statut de disponibilité d'un utilisateur dans un outil de communication. Certaines formes, comme les images qui imitent des panneaux de signalisation, sont utilisées pour accompagner un message, un avertissement ou signaler une erreur.

En générale, ils s'agit de symboles, selon la théorie sémiotique de Peirce. C'est à dire, des signes dont la signification à été attribuée d'une façon arbitraire.

Cette dimension considère aussi les possibles préférences sur les représentations graphiques. Par exemple, des utilisateurs ruraux et non alphabétisés de Bangalore favorisent les images et les idées les plus proches de la réalité (MEDHI, SAGAR et TOYAMA, 2006).

7. « les éléments physiques —naturels et artificiels— qui entourent une personne ... »

Les représentations non-linguistiques nasa et leur possible place dans l'interaction : Parmi les symboles existants dans la culture nasa, il y en a deux à souligner : la spirale et le *ũhza yafx*, symbole en forme de losange. D'après LASSO SAMBONY et CALAMBÁS SÁNCHEZ (2005), la spirale est liée au parcours de la vie, l'évolution, les connaissances, le temps, parmi d'autres rapports. De son côté, le losange a aussi plusieurs significations relatives à la vision du monde et la vie : l'organisation spirituelle, l'habilité pour s'échapper des dangers, et le corps féminin comme berceau. L'importance de ces deux symboles est visible dans l'ensemble des créations artistiques, telles que peintures, tissages et même de danses. Dans l'interface des ordinateurs, ces figures peuvent donner lieu à la configuration de la position des ensemble d'objets, à montrer l'évolution d'un processus, ou même, comme il sera décrit dans l'Annexe, à définir la forme d'un clavier graphique.

Conclusion de conception : l'usage du losange dans l'interface met en évidence des éléments importants et montre explicitement le rapport de l'outil avec la culture nasa.

8 Travail de terrain et prototypes de validation

Pendant les mois d'avril à août 2010, un séjour de recherche a été réalisé en Colombie afin de valider le modèle culturel et les hypothèses de conception concernant la culture nasa [8]. Le travail a été développé au sein de deux écoles nasa, situées sur les flancs opposés de la cordillère : les *resguardos* de Tumbichucue et Caldono. Pour valider les hypothèses nous avons mis en œuvre et évalué la conception de deux outils avec les élèves et enseignants des deux écoles : (1) un jeu éducatif et (2) une plateforme éducative comme système informatique de base pour les écoles. Cette section résume le travail d'élaboration de ces deux outils.

Conception d'un jeu éducatif numérique. Pour la conception de cet outil, nous avons suivi une méthode basée sur celle proposé par KAM et al. (2009), qui consiste en (1) l'évaluation de l'usage de jeux numériques exogènes, (2) l'observation des jeux locaux et l'analyse selon des patrons de jeux de BJÖRK et HOLOPAINEN (2005) et (3) l'élaboration d'outils ludiques. L'idée de conception choisie a été la création d'un jeu compétitif inspiré d'un type de toupie, bien connue par les enfant nasa, appelée *peçxukwe çxuga* (toupie à fouetter). Il s'agit d'une toupie d'une dizaine de centimètres, fabriquée en bois, qu'il faut frapper avec un fouet de fibres végétales pour la garder en rotation. Dans la version numérique, différents joueurs sont en concurrence et doivent répondre correctement à des défis en langue nasa pour faire tourner leur toupies.

L'élaboration de ce jeu a pris en compte principalement deux dimensions de la culture, le modèle culturel décrit dans la section précédente : (1) *L'environnement et technologie :* (a) ressources informatiques limitées ainsi que (b) les jouets et outils ludiques locaux. (2) *Organisation sociale :* la valeur donnée au travail collectif.

8. L'auteur tient à remercier l'Université européenne de Bretagne et son Collège doctoral international pour la bourse de mobilité qui a permit d'effectuer ce travail de terrain.

FIGURE 1 – (a) Enfant jouant avec une toupie à fouetter. (b) Session de conception collective de la version numérique.

La dynamique du jeu a été testée avec les élèves des écoles, en utilisant le tableau d'un salon comme base pour le prototype. Pour cela, Abelardo Ramos, linguiste nasa, a posé des défis en langue nasa que les groupes d'enfants devaient surmonter pour donner de l'impulsion à leur toupies (Voir Figure 1).

Une plateforme éducative pour les écoles nasa. Pour concevoir cet outil, nous avons considéré des hypothèses 1 et 3 décrites dans la section précédente. L'idée initiale présentée aux groupes d'évaluateurs a été de créer une plateforme de travail coopératif multi-dispositif avec deux espaces dans l'interface, un individuel et un collectif. L'élément central dans l'espace individuel est un losange constitué par les représentations des outils disponibles dans l'interface. L'espace collectif serait une analogie au foyer à trois pierres. Les utilisateurs connectés au système au travers d'autres terminaux seraient représentés autour du foyer.

Similaire à la méthode de conception du jeu, cette idée a été évaluée avec des élèves et enseignants en utilisant le tableau d'un salon comme base de prototypage. Parmi les réactions le plus importantes, les évaluateurs comprenaient la métaphore du foyer, en validant l'Hypothèse 3. Cependant, ils s'accordent sur le besoin d'un deuxième espace collectif, analogie au *resguardo*, car le foyer est limité à la famille et proches, tandis que le *resguardo* est propice au travail avec la totalité de la communauté.

Les résultats de cette évaluation a permis de réaliser une première adaptation de la plateforme Sugar [9] à la culture nasa. La Figure 2 illustre l'espace individuel et le premier espace collectif de cette adaptation.

9. Sugar : http ://sugarlabs.org

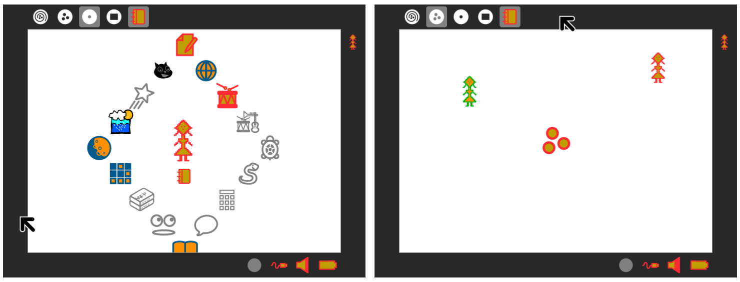


FIGURE 2 – Adaptation des deux espace de travail dans la plateforme Sugar selon des critères nasa.

9 Une méthode pour la description de la conception

La deuxième question de recherche concerne le manque de méthodes pour informer les producteurs d'outils sur comment résoudre un besoin de conception au sein d'un groupe d'utilisateurs. Celle-ci peut être comprise comme un problème de sélection : *Quelle solution de conception est la plus adaptée pour un contexte socioculturel spécifique et pour quoi ?*

Cette question est d'abord liée à la représentation de l'influence de la culture sur les processus de conception, ainsi sa réponse demande un soutien théorique de modélisation. Comme nous en avons conclu auparavant, chacune des méthodes que nous avons décrites dans les Sections 5 et 6 fournissent une solution partielle à cette problématique. Les *modèles de conception d'interfaces* rendent possible la représentation de manière formelle du système interactif, mais il ne décrivent pas les raisons du problème résolu ni les conséquences de la solution. Quant aux *patrons de conception*, ils apportent une structure permettant d'évaluer le problème, décrivent la solution à un niveau abstrait et réutilisable ainsi que ses répercussions. L'information apportée par les patrons peut être enrichie par les modèles de *logique de conception*, en décrivant quelles options ont été considérées pour résoudre le problème et quels critères ont été pris en considération pour les évaluer.

En conséquence, notre solution intègre ces trois méthodes, en construisant une structure semi-formelle qui décrit les problèmes, les possibles options apportant une solution, les différents niveaux d'abstraction de l'option, ainsi que le rapport avec les facteurs socioculturels associés. Cette structure, basée sur les patrons de conception, est synthétisée ci-dessous :

Nom : Un nom significatif pour le patron.
Intention : Courte description du problème de conception particulière que le patron aide à résoudre.
Catégories culturelles : Les catégories culturelles du modèle liées au patron.
Motivation : Un scénario décrivant le problème et comment les possibles solution s'adressent à lui.

Options : Les différents solutions de conception considérées pour résoudre le problème.
Critères : Les différents critères pris en compte pour évaluer les options possibles pour résoudre le problème.
Évaluation : Le résumé de l'évaluation des solution par rapport aux critères. Ce résumé a la forme d'un tableau selon proposé par le modèle QOC.
Applicabilité : Les situations dans lesquelles la solution de conception choisie peut être utilisée.
Structure : Représentation graphique des tâches, interfaces concrètes, classes et d'autres modèles décrivant la composition de la solution.
Participants : Une description détaillée de chaque élément qui fait partie de la solution.
Conséquences : Quels sont les résultats de l'utilisation de ce patron ? Comment la solution atteint son objectif ?
Applications connues : Exemples de l'utilisation du patron dans de systèmes réels.
Patrons associés : D'autres patrons de conception liés à ce couple problème-solution, ainsi qu'une description des différences entre eux.

Dans le cadre de la thèse, nous avons élaboré six patrons de conception liés à notre expérience avec la culture nasa. Étant donnée la longueur de chaque patron, nous nous limitons dans ce résumé à décrire la solution pour la *Saisie de texte* en nasa yuwe. Ce patron est annexe à la fin du document. D'autres exemples des patrons avec un rapport à la culture nasa incluent : *Distribution graphique significative d'un groupe d'éléments culturellement*, *Partage d'activités* et *L'usage collectif des ressources limitées*. La Figure 3 synthétise et montre les rapport entre les six patrons, ainsi que les facteurs culturels impliqués dans chacun.

Au-delà d'une méthode pour décrire de solutions réutilisables à problèmes spécifiques, la structure que nous avons élaborée rend possible l'illustration d'exemples au sein d'un contexte précis. Le pouvoir de ces structures est que le lecteur peut comprendre comment la solution a été conçue au sein du contexte du problème, il peut identifier des similitudes et différences avec ses propres besoins de conception et considérer une solution en conséquence.

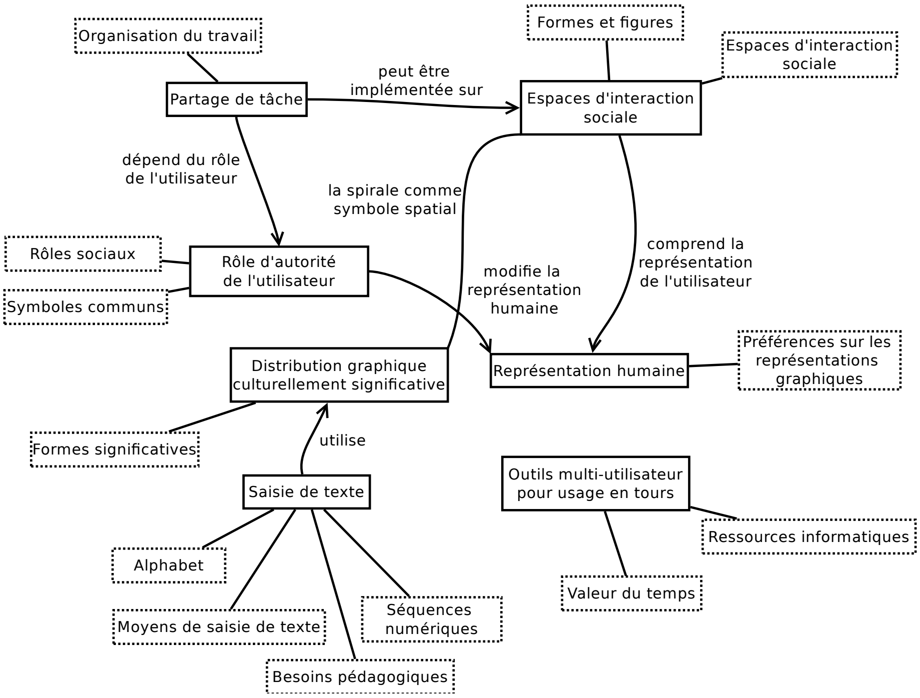


FIGURE 3 – Liens entre les patrons de conception (rectangles à lignes continues) et les caractéristiques culturelles impliquées (rectangles à lignes pointillées).

10 Conclusions

Comme il a été dit auparavant, le contexte de recherche de cette thèse est la production d'outils dans les rencontres entre différentes cultures. Des expériences précédentes ont montré que la culture des utilisateurs et producteurs de technologie est implicite dans plusieurs aspects des processus de conception et développement. Ainsi, nous avons identifié le besoin d'un support théorique d'aide dans ce contexte inter-culturel. Cette problématique de recherche est composée par deux axes. Le premier vise à fournir les producteurs d'outils d'un moyen pour étudier le contexte socioculturel des utilisateurs. Le second a pour objectif de créer une base solide pour représenter et décrire l'influence de la culture sur les processus de conception.

Un modèle culturel pour le développement d'outils informatiques. La plupart de processus de conception ou adaptation d'outils dans un contexte culturel prennent en compte des caractéristiques relativement faciles à étudier (langue, formats de chiffres, formats de dates, etc.) Le modèle culturel que nous avons développé considère cinq grandes dimensions, y compris des facteurs qui ont besoin d'un étude plus approfondi de la culture : langage oral et écrit, l'organisation sociale, les structures spatiales, l'environnement et technologie et les signes non-linguistiques.

Ces dimensions sont concentrées sur de conséquences culturelles liées à de problèmes de représentation et signification. Il est possible de comprendre cette problématique en considérant les caractéristiques que l'interaction entre humains et machines partage avec les processus de communication et signification. Comme nous avons décrit dans ce texte, l'interprétation de signes intervenant dans la communication dépend en grande partie de la culture. En conséquence, nous avons construit le modèle culturel comme un outil pour la production de codes d'interaction appropriés à la culture des utilisateurs.

Ce modèle a été validé simultanément avec la production de deux outils pour les écoles nasa. Le travail de terrain, ainsi que la conception participative avec élèves et enseignants, ont permit d'évaluer un ensemble d'hypothèses liées à l'élaboration d'outils et de raffiner les caractéristiques prises en compte par le modèle.

Une approche de description d'information sur la conception d'outils. Étant donné que un modèle est la représentation d'une réalité, les modèles des conception –d'interface utilisateur– sont une première approche pour décrire comment la culture a influencé l'élaboration d'un outil. Cependant, les modèles actuels d'interfaces sont en développement et ont besoin de gagner de stabilité. Au même temps, les modèles de conception représentent le système tel qu'il est, et ne fournissent pas de l'information sur le raisonnement derrière le processus d'élaboration. Elle ne décrivent pas le besoin pour lequel le système a été conçu, ni quelles alternatives on été prises en compte. Afin de palier ce manque, notre solution intègre les modèles de conception à la structure des patrons de conception et des modèles de logique de conception.

Cette approche nous permet de structurer six patrons de conception qui décrivent comment nous avons produit les solutions conçu sur terrain, dans les écoles nasa. En plus de l'information réutilisable, ces patrons présentent des exemples bien détaillés qui aident à comprendre comment résoudre de problèmes similaires.

Il est important de souligner que cette thèse a réussi à joindre les travaux de deux disciplines complémentaires : les modèles élaborés par les sciences sociales et les approches de conception des sciences en informatique. Les patrons de conception rend possible la description de comment une large étendue de facteurs socioculturels est implicite dans les composants d'un système interactif.

A Patron : Saisie de texte en nasa yuwe

Intention : fournir une méthode graphique pour permettre aux utilisateurs de saisir n'importe quel graphème du nasa yuwe. Celle ci est une alternative aux claviers en espagnol latino-américain, qui manquent des caractères des voyelles nasales et la lettre ç.

Cultural categories : Ce patron est lié aux conséquences de quatre caractéristiques culturelles :

– ***Langage :*** *Alphabet*. L'alphabet nasa yuwe est basé sur des caractères latins. En plus des 23 caractères « basiques », deux diacritiques s'ajoutent pour représenter la lettre ç et la nasalisation dans les voyelles.
– ***Environnement et technologie :*** *Moyens de saisie de texte*. Les clavier en espagnol latino-américain sont le plus communs dans le contexte nasa.
– ***Organisation sociale :*** *Besoins pédagogiques*. Identification des digraphes et trigraphes comme des unités phonétiques.
– ***Signes non linguistiques :*** *Séquences numériques*. L'enseignement de l'alphabet nasa suit un ordre basé sur la Vision du monde, représenté dans le nombre de consonnes apprises : 4-2-4-1-4. (Ce concept est décrit dans la Section 7.2.1 du manuscrit de la thèse).

Motivation : Le besoin d'une interface de saisie de texte a deux raisons principales :

1. Les clavier disponibles dans le territoire nasa manquent des options pour saisir les voyelles nasales, représentées par le diacritique tilde (˜) et la lettre ç.
2. Il existe 38 digraphes et trigraphes [10] parmi les 69 graphèmes du nasa yuwe. Par de raisons pédagogiques, il est important de montrer, aux apprentis de l'alphabet, que ces graphèmes représentent d'unités phonétiques.

Options :

1. Clavier matériel en espagnol latino-américain
2. Outil graphique complémentaire pour le graphèmes manquants dans le clavier

ĩ	ẽ	ã	ũ	ç

3. Clavier complète sur écran

10. Considérant les voyelles i', e', ã', ũ' comme des graphes simples.

Critères :

1. Couverture de l'alphabet
2. Identification des digraphes et trigraphes comme unités phonétiques
3. Économie de l'espace de l'interface
4. Culturellement significative
5. Considération de l'ordre d'apprentissage de l'alphabet

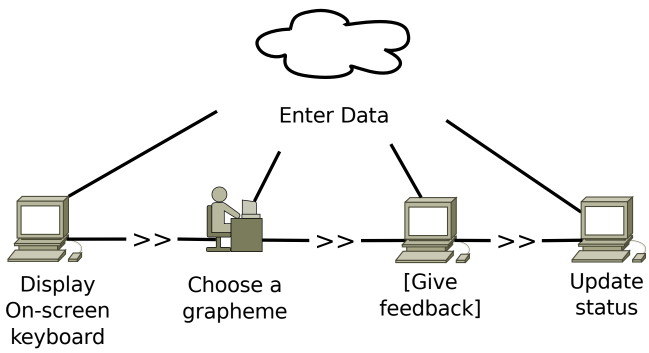
Évaluation :

	Critère 1	Critère 2	Critère 3	Critère 4	Critère 5
Option 1	-	-	+	-	-
Option 2	+	-	-	-	-
Option 3	+	+	-	+	+

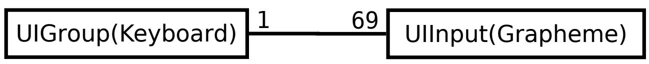
Applicabilité : Systèmes avec un support incomplet pour l'écriture du nasa yuwe.

Structure :

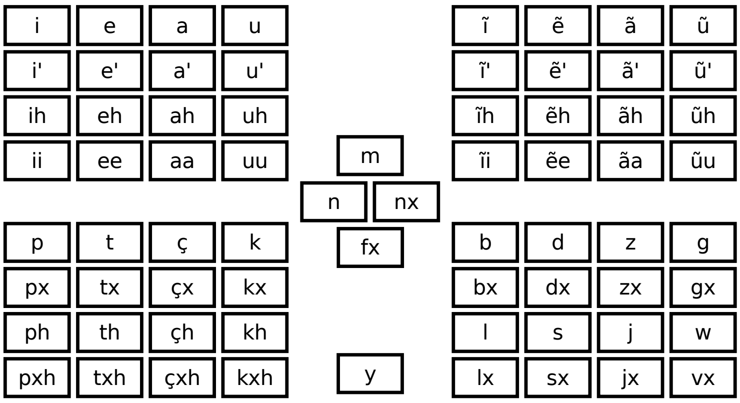
– Tâches :



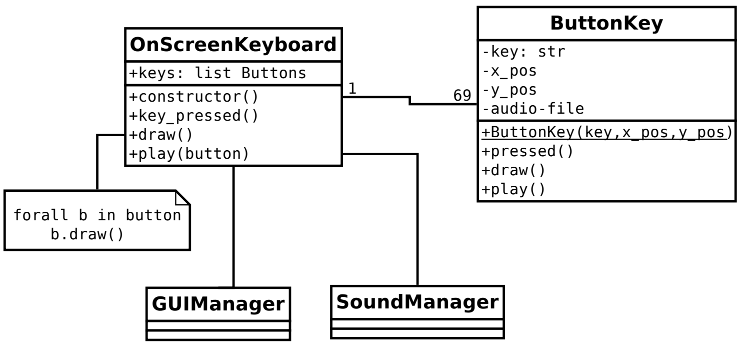
– Interacteurs abstraits :



– Disposition graphique concrète :



– Classes :



Participants :
– Tâches :
  – **Choose a grapheme** : L'utilisateur sélectionne un graphème du clavier sur écran.
  – **Give feedback** : L'ordinateur reproduit le son correspondant au graphème sélectionné (Tâche facultative).
– Classes :
  – **ButtonKey** : Définit un bouton à être utilisé comme touche.
  – **OnScreenKeyboard** : Comprend toute les touches, crée tous les boutons et attribue leur position relative sur l'interface graphique.
  – **GUIManager** : Défini par la bibliothèque graphique utilisée par le système. Il doit être capable de déclencher et manipuler d'évènements d'interaction.
  – **SoundManager** : Classe facultative responsable de reproduire une réponse auditive à la sélection d'un graphème.

Conséquences : Ce patron crée un clavier sur écran composé de boutons pour chaque graphème du nasa yuwe. Un inconvénient de cette solution est qu'elle a besoin d'un espace considérable dans l'interface graphique.

Applications connues : (1) Clavier utilisée sur *Comunidad virtual de apoyo a los procesos de etnoeducación nasa* http ://www.ewa.edu.co. (2) Çut pwese'je (le jeu du maïs).

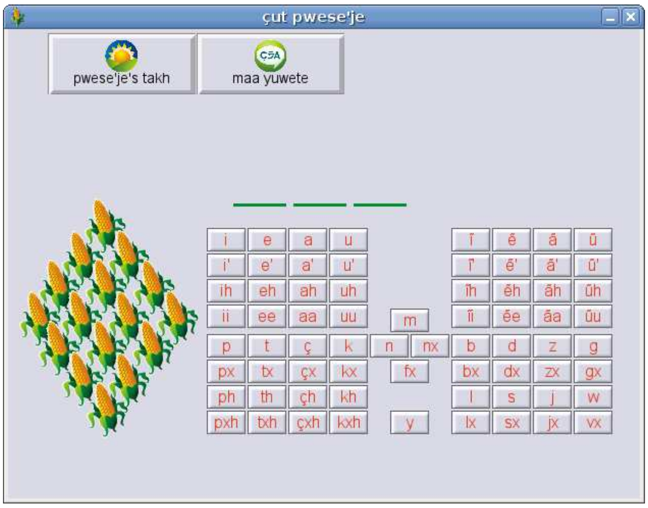


FIGURE 4 – Le jeu du maïs

Patrons associés : Aucun.